Draft Remedial Investigation/Feasibility Study Work Plan

Bremerton Gas Works Site

Prepared for: Cascade Natural Gas Corporation

Aspect Project No. 080239-005 •Anchor QEA Project No. 131014-01.01
April 17, 2015

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Abbreviations

Anchor QEA	Anchor QEA, LLC
AOC	Administrative Settlement Agreement and Order on Consent for Remedial Investigation Feasibility Study
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting, LLC
AST	aboveground storage tank
bgs	below ground surface
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethylbenzene, and xylenes
Cascade	Cascade Natural Gas Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
City	City of Bremerton
COC	contaminant of concern
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSM	conceptual site model
CSO	combined sewer overflow
DNAPL	dense non-aqueous phase liquid
DNR	Washington State Department of Natural Resources
DQO	data quality objective
DU	data usability
E&E	Ecology & Environment, Inc.
Ecology	Washington State Department of Ecology
EcoSSL	ecological soil screening level
EDD	electronic data deliverable
EM	electromagnetic
ENVVEST	Environmental Investment Project
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ER-L	effect range-low
ER-M	effect range-medium
FS	Feasibility Study
GPR	ground-penetrating radar
HHRA	human health risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
ISA	initial study area
KPHD	Kitsap Public Health District
Lent's	Lents and Blombergs
LNAPL	light non-aqueous phase liquid
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MCL	maximum contaminant level
MDAC	minimum data acceptability criteria
mg/kg	milligram(s) per kilogram
MGP	manufactured gas plant
MTCA	Washington State Model Toxics Control Act

NAPL	non-aqueous phase liquid
NOAA	National Oceanographic and Atmospheric Administration
NRHP	National Register of Historic Places
Order	Administrative Order for a Pollution Incident
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PHS	Priority Habitats and Species Program
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSAMP	Puget Sound Assessment and Monitoring Program
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSL	regional screening level
SCO	sediment cleanup objective
Site	Bremerton Gas Works Site
SMS	Sediment Management Standards
SOW	Statement of Work
SPME	solid-phase microextraction
SQAPP	Sampling and Quality Assurance Project Plan
SVOC	semivolatile organic compound
TBA	Targeted Brownfields Assessment
TBC	to be considered
TCRA	time critical removal action
TEQ	toxic equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TS	total solids
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
USCG	U.S. Coast Guard
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WDFW	Washington Department of Fish and Wildlife

1 Introduction

Cascade Natural Gas Corporation (Cascade) is conducting a Remedial Investigation (RI) and Feasibility Study (FS) at the Bremerton Gas Works Site (Site) under the direction of the U.S. Environmental Protection Agency (EPA). This Draft Remedial Investigation/Feasibility Study Work Plan (Work Plan) presents detailed descriptions of the procedures and activities to be performed to complete the RI/FS. This Work Plan was prepared as required by the Administrative Settlement Agreement and Order on Consent for Remedial Investigation Feasibility Study (AOC; EPA, 2013a) and accompanying Statement of Work (SOW) for the Bremerton Gas Works Site.

The Site encompasses approximately 2.8 acres of industrial upland property and marine beachfront on the south shore of the Port Washington Narrows in Bremerton, Kitsap County, Washington. The Site location is depicted on Figure 1-1.

A manufactured gas plant (MGP) formerly operated on a portion of the Site. Other historical uses on or near the Site include bulk petroleum storage and distribution, equipment storage, boat maintenance, metal fabrication, and automobile salvage. Previous investigations have identified elevated concentrations of hazardous substances in soil, groundwater, and sediments, attributable to these historical activities. Currently, the Site is largely vacant and unused.

In accordance with the AOC and SOW, this Work Plan includes detailed sampling and quality assurance project plans. The Sampling and Quality Assurance Project Plan (SQAPP) for the upland and marine portions of the Site are included as Appendices A and B, respectively.

1.1 Objectives of the RI/FS

The objectives the RI/FS for the Site are the following:

1. Investigate and define physical, chemical and biological characteristics of the Site;
2. Define the sources, nature, and distribution of contaminants;
3. Provide sufficient information to calculate and assess the current and future potential risks to human health and the environment; and
4. Provide sufficient information to identify and evaluate remedial alternatives, conceptually design the remedial alternatives, and select a remedy.

The RI/FS will be conducted in accordance with the provisions of the AOC, SOW, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Contingency Plan, and EPA guidance, including, but not limited to, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a), and Guidance for Data Useability in Risk Assessment (EPA 1992).

1.2 Work Plan Organization

This Work Plan is organized into the following sections:

- Section 2 – Background and Setting. This section provides a description of the Site location; a summary of known current and historical uses of the Site and adjacent properties and aquatic lands; a summary of the Site environmental setting including regional and Site geology and hydrogeology; a discussion of current demographics and land use; a summary of the characteristics of the Port Washington Narrows; and a description of natural and cultural resources in the Site vicinity.
- Section 3 – Initial Evaluation. Section 3 presents the regulatory requirements and provides a summary of the previous work conducted that is relevant to the RI/FS including previous Site investigations, previous removal actions, and available existing data. A summary of the existing data for soil, groundwater, and sediment is also presented in this section.
- Section 4 – Preliminary Conceptual Site Model. This section presents a conceptual understanding of the Site based on the information discussed in Sections 2 and 3, including a summary of the contaminants of potential concern, their sources, transport mechanisms, exposure pathways and receptors.
- Section 5 – Potential Remedial Approaches. Section 5 includes a discussion of potentially applicable remedial technologies for the Site, a summary of remedial approaches that have been implemented at similar sites, and the data needed to develop and evaluate remedial alternatives for the Site.
- Section 6 – RI/FS Approach. Section 6 presents the approach for completing the RI/FS and the rationale behind the approach, including identification of the data needs, a summary of the risk assessment approach, a general discussion of the components of the upland and marine portions of the RI/FS, and potential contingent actions.
- Section 7 – RI/FS Tasks. Section 7 presents a summary of the tasks to be conducted for completion of the RI/FS.
- Section 8 – Schedule. This section presents the schedule for completion of the RI/FS including a field data collection schedule and the general schedule for subsequent tasks and reports.
- Section 9 – Project Management Plan. Section 9 presents the project management plan, including a data management plan.
- Section 10 – References. References cited within the Work Plan are listed in this section.

2 Background and Setting

This section describes the property upon which the former gas works was located and the properties surrounding the former gas works and discusses the operational and regulatory history of those properties.

2.1 Site Location and Description

The former gas works was located between Thompson Drive and Pennsylvania Avenue (Figure 2-1) on approximately 2.8 acres of property along the south shore of Port Washington Narrows in Bremerton, Washington. The historical street addresses for the former gas works included 1720 and 1800 Thompson Drive.

The real property upon which the former gas works was located (Former Gas Works Property) relative to current parcel boundaries is shown on Figure 2-1. Due to a boundary line adjustment in 1992, the Former Gas Works Property includes portions of two existing tax parcels:

- **Kitsap County Parcel No. 3711-000-0010-0409 (McConkey Property).** This parcel is owned by the McConkey Family Trust. The former gas works covered the entire parcel. No current or historical street address has been identified for this parcel.

- **Kitsap County Parcel No. 3741-000-022-0101 at 1701 Pennsylvania Avenue (Sesko Property).** This parcel is owned by Natasha Sesko. The former gas works covered the northwestern portion of this parcel.

The following properties are located near the Former Gas Works Property and have had either suspected or confirmed releases of contaminants from historical operations unrelated to the former gas works:

- **1723 Pennsylvania Avenue (Penn Plaza Property).** This property is owned by Penn Plaza Storage, LLC. There are multiple street addresses associated with this property, but it is listed in the Kitsap County assessor's database as 1723 Pennsylvania Avenue.

- **1701 Thompson Drive (Former ARCO Property).** This property is owned by Pipeworks Mechanical & Service, Inc. It is located southwest of the Former Gas Works Property, across Thompson Drive.

- **1702 Pennsylvania Avenue (Former SC Fuels Property).** This property is owned by NFS Properties 2, LLC. It is located east of the Sesko Property, across Pennsylvania Avenue.

The Port Washington Narrows is located north of the McConkey, Sesko, and Former SC Fuels Properties. The Port Washington Narrows consists of aquatic lands owned by the State of Washington and managed by the Washington State Department of Natural Resources (DNR).

2.2 Site Uses Prior to 1930

The Port Washington Narrows and the adjacent uplands are located in the traditional territory of the Suquamish Tribe (Tribe), a Southern Coast Salish community speaking a dialect of the Southern Lushootseed language (Suttles and Lane 1990). Shoreline locations in Dyes Inlet would have been available after stabilization of sea levels in the mid-Holocene (Thorson 1980); therefore, Native American use of the area may date back more than 5,000 years. A variety of traditional activities took place in the general vicinity. In 1855, the Tribe signed the Treaty of Point Elliott, which ceded lands and established the reservation at Port Madison. The Tribe retained "the right of taking fish at usual and accustomed grounds and stations" (Treaty of Point Elliott 1855), and the Port Washington Narrows is within the Tribe's adjudicated Usual and Accustomed area.

2.3 Current and Historical Use and Operations

Historical use and operations on the properties and aquatic lands are based on historical records, including aerial photographs, interviews with current and former workers, owners, area residents, historical maps, deeds, Washington State Department of Ecology (Ecology) records, City of Bremerton (City) records, and DNR lease records. A number of historical documents are included in previous assessments of historical Site use (TechLaw 2006; Hart Crowser 2007). Available and relevant historical records are provided in Appendix C for reference.

Historical and current operations on the Former Gas Works Property (which consists of the entire McConkey Property and a portion of the Sesko Property) as well as historical and current operations on the other portion of the Sesko Property are described in Section 2.3.1. Historical and current operations on adjoining properties are described in Section 2.3.2.

2.3.1 Operations on McConkey and Sesko Properties

2.3.1.1 Former Gas Works Operations

In 1930, the Former Gas Works Property was developed as a gas works (a.k.a., manufactured gas plant, or MGP). Gas works were a common industry in large and small towns throughout the United States and Europe from approximately the mid-1800s to the mid-1900s. At a gas works, coal, coke, and/or petroleum products were heated in furnaces to produce manufactured gas, which was subsequently distributed via a gas piping network to the surrounding homes and businesses for heating, cooking, and lighting. Gas works used or generated a number of products and byproducts, including non-aqueous phase liquids (NAPLs) such as oils and tars, aqueous waste streams, and solid materials containing chemicals that may pose a risk to human health or the environment because they are toxic or carcinogenic (resulting in cancer effects). These contaminants include hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and polycyclic aromatic hydrocarbons (PAHs), which can persist for a long time in the environment. Contaminant releases from historical gas works operations at other locations have resulted in sites where contamination remains in the subsurface as NAPLs, sorbed to soil or sediments or dissolved in the groundwater.

Because of the potential hazards posed by historical gas works facilities, these facilities are often the focus of state-led or federally led efforts to investigate and clean up contamination to protect human health and the environment. To characterize and remediate these facilities, it is important to understand traditional gas works operations, the types of contaminants that may be present, and where contaminants may have been released. This section provides a summary of what is known about operations at the former gas works based on historical documentation and what is assumed based on typical gas works operations. This section also identifies the contaminants usually associated with gas works feedstocks, fuels, and byproducts that may be present at the Site. Uncertainties about historical practices and potential releases will be addressed through field investigations as described in this Work Plan. Further discussion of potential release mechanisms and transport of contaminants in the subsurface is provided in Section 4, Preliminary Conceptual Site Model.

The operational history of the former gas works is as follows:

- **1930 to 1931.** The former gas works was constructed by the Western Gas and Utilities Corporation.[1] It included a dock on aquatic lands initially leased from the DNR on November 25, 1930 (Former Gas Works Dock).

- **1931 to 1955**. Manufactured gas was produced using the carbureted water-gas process, from feedstocks of coal, coke briquettes, and petroleum products.[2] In the 1940s, a standby plant for producing natural gas by blending liquefied petroleum (butane or propane) and air was installed. Gas produced at the Former Gas Works Property in the 1940s and 1950s was from manufactured gas and from butane-air. In approximately 1955 (Simonson 1997b), manufactured gas operations ceased, and all gas was produced from butane-air mixing.

- **1955 to 1963.** Natural gas was produced from butane-air mixing. In 1963, with the completion of a natural gas pipeline to the region, gas production ceased.

- **1963 to 1972.** Some of the structures and tanks were removed between 1964 and 1965, and the concrete piers supporting the tanks were jackhammered and hauled away (White 1998). The former plant building was reportedly used for pipe storage and, for a short time, magnesium mining research (*Bremerton Sun* 1972). In 1972, the remaining structures, including the former plant building, were sold and dismantled.

In 1972, the Former Gas Works Property was acquired by Harold D. and L. Irene Lent and Theodore and Marian J. Blomberg, doing business as "Lent, Blomberg, Lent." The Lent and Blomberg families operated several businesses in the vicinity of the Former Gas Works Property, including an oil distribution business on the Sesko Property under the

[1] In 1931, the Western Gas and Utilities Corporation changed its name to the Western Gas Company of Washington. The Western Gas and Utilities Corporation and the Western Gas Company of Washington are collectively referred to herein as "Western."

[2] Typically, diesel-range fuel oils were used for petroleum feedstock for the carbureted water-gas process (Hatheway 2012). However, one historical map (Sanborn 1946) indicates that gasoline and fuel oil were stored in the northeast corner of the Former Gas Works Property.

name Lents, Inc. (see further discussion in Section 2.3.1.3). All entities and individuals associated with the Lents and Blombergs are referred to in this Work Plan as "Lent's."

In 1979, Paul and Margaret McConkey acquired the majority of the Former Gas Works Property. The McConkeys acquired the remainder of the Former Gas Works Property in 1985. A portion of the Former Gas Works Property was sold to William Sesko in 1992.

The summary of gas works operations provided in this section combines available historical information about the layout and operations of the former gas works with information compiled from multiple sources regarding the operations of typical manufactured gas facilities, including generated byproducts and likely sources of releases of hazardous substances. Whereas this summary provides an overview of operations at the former gas works, it likely does not provide a complete picture of all sources, disposal areas, and spills and/or releases that may have occurred, which will be investigated primarily through the collection and evaluation of data as described in this Work Plan. Chemical feedstocks and potential byproducts typical of carbureted water-gas production[3] include the following:

- **Feedstock and Fuels: Gasoline and Diesel Fuel Oil, Coal, or Coke Briquettes**. The contaminants potentially associated with feedstock and fuels include the following:
  - BTEX;
  - Naphthalenes; and
  - PAHs.
- **Byproducts: Light Oil, Carbureted Water-Gas Tar, Ash, Clinker, Slag, Soot, and Spent Purifier Filter Media.** The contaminants potentially associated with byproducts include the following:
  - BTEX;
  - Naphthalenes;
  - PAHs;
  - Phenols;
  - Other semivolatile organic compounds (SVOCs), including creosol, carbazole, and dibenzofuran.

Section 4.4 provides further discussion of the Site-specific COPCs.

[3] Two byproducts typically generated at coal and/or oil gas plants, ammoniacal liquor and lampblack (carbon soot), were generally not generated in significant quantities by the carbureted water-gas process (Hatheway 2012).

Production of natural gas using liquefied petroleum (butane or propane) blended with air is not anticipated to have resulted in contamination of the subsurface because butane and propane are gases at atmospheric conditions.

A flow chart showing the gas works process as understood at the Site (based on available plant maps and typical carbureted water-gas operations), including the production of byproducts, is presented on Figure 2-2. The locations of key plant features are shown on Figure 2-3. The general sequence of operations is as follows:

- **Product Delivery and Storage.** Solid feedstocks (coal and coke briquettes) were transported to the Site by barge and offloaded via a winch to a storage slab located in the northwest corner of the Former Gas Works Property. Petroleum products were also delivered to the former gas works via barge and conveyed via a pipeline up the Former Gas Works Dock to storage tanks located in the northeast corner of the Former Gas Works Property.
- **Gas Generation and Purification.** These operations were located in the north-central portion of the Former Gas Works Property (Figure 2-3). Two generator sets (furnaces) were located in the main plant building: one in the northern portion of the building and one in the middle of the building (Simonson, 1997b). The main plant building had a concrete floor (Simonson, 1997b). Coal and coke were placed in the generators and heated, and fuel oil was sprayed into the generators to produce gas. The resulting gas stream was then passed through a series of devices to cool the gas and remove impurities. These devices are described below:
- **Scrubber.** After gas generation comes clarification, in which tar is separated from the gas using a scrubber or similar equipment. These devices are typically located adjacent to the generator sets. A historical plant map shows the scrubber located directly west of the generator sets. A former plant worker indicated that the scrubber consisted of a tank with wooden slots and water to "wash out" the gas (Simonson 1997b). An engineer's report (Tymstra 1942) indicates that wood chips and excelsior (i.e., wood shavings) were used to remove tar from the gas.

  The clarification process typically produced tar, tar-soaked wood chips or shavings, gas liquor (aqueous solutions containing dissolved and suspended tar particles), and tar-water emulsions. Light oils may also have been produced in the scrubbing process. Tar-water emulsions from scrubbers were typically removed from clarification equipment and transported to residual management areas to separate tar from the water (Hatheway 2012). The fate of byproducts and residuals is discussed in the bullet "Residuals Management."

  - **Gas Holder.** A large gas holder was located south of the scrubber, west of the main plant building. The bottom of the gas holder was reportedly 15 feet deep and contained tar and water (Simonson 1997a). The materials used to construct the base of the gas holder are known.
  - **Purifier.** Gas was passed through a bed of filter media to remove impurities such as sulfide from the gas. Typical filter media included wood chips and/or iron oxide. An engineer's report (Tymstra 1942) indicated that iron-oxide-covered chips were used at the gas works to remove sulfur compounds from gas. Multiple purifiers in parallel were typically installed to allow changeout of purifier media without interrupting the process

(Hatheway 2012). Three purifiers were located at the Former Gas Works Property south of the large gas holder. In addition to the generation of spent purifier media, which included some accumulated tar (Tymstra 1942), some liquid streams (including tar, gas liquor, and light oil) may have condensed during purification and were typically manually removed from the purifier box (Hatheway 2012). The fate of these byproducts is discussed in the following bullet.

- **Residuals Management.** In addition to the gas produced by the manufactured gas process, residual materials were also produced and separated from the gas at several steps during the process. These residuals were intermediate waste streams typically managed on-site and further processed to create byproducts for disposal or reuse. Residuals from the manufactured gas process included the following:
    - **Tar-Water Emulsion.** Tar removed from the gas stream, particularly from the condenser, was often a tar-water emulsion. Tar required a low water content to be saleable. Tar-water emulsions were typically removed from clarification equipment and transported to residual management areas to separate the tar from the water (Hatheway 2012). Tar and water were typically separated by placing the emulsion in pits, cisterns, or tar wells (typically shallow boxes that may be lined or unlined) and allowing the tar to settle out. A former plant map shows tar wells and a residue cistern located west of the purifiers near the edge of the ravine adjacent to the former gas works (Former Ravine). A former resident recalled a tar pit located on the southwest corner of the Former Gas Works Property (Judd 2014), and an engineer's report (Tymstra 1942) noted, "The tar emulsion is dumped in shallow pits dug at random in the ground." A historical journal (Perry 2002) indicated that the former gas works "had a pond for dumping surplus creosote-type fluids. This would overflow and the material would go into the channel." It is unknown how tar-water emulsions were transported to these areas or how tar was transported from these areas to the tar storage tank, which was located on the south side of the Former Gas Works Property.
- **Storage, Distribution, and Disposal of Gas and Byproducts.** Following purification, finished gas was stored and distributed via underground piping to the gas service area. Finished gas and byproducts of the manufactured gas process were collected, stored, and used or disposed of as follows:
    - **Finished Gas.** Gas that had passed through the scrubbers and purifiers was pumped through compressors located in the engine room (south of the main plant building) and stored in finished gas storage tanks located south of the main operations area. Gas was piped from the finished gas tanks to the gas distribution system along an 8-inch-diameter gas main located in Thompson Avenue. Typically in manufactured gas distribution systems, a minor amount of oil would condense within the initial section of distribution piping, which would be collected in a drip tank located near the facility (Hatheway 2012). A drip tank located just south of the Former Gas Works Property (Figure 2-3) is shown on a historical plant sketch.

- **Light Oil.** Light oils typically contain one- or two-ring aromatic compounds, such as BTEX, and naphthalenes and have a density less than that of water (i.e., light, non-aqueous phase liquids [LNAPLs]). Light oils were sometimes reused in the carbureted water-gas process. According to a former worker, light oils were produced in small quantities at the former gas works and stored in a tank south of the finished gas storage tanks, and they were occasionally sprayed to control weeds in the southwest corner of the Former Gas Works Property or as automotive fuel for workers' vehicles (Simonson 1997b).
- **Carbureted Water-Gas Tar.** This tar typically contains both light aromatics (e.g., BTEX) and semivolatile hydrocarbons. Semivolatiles in coal tar primarily consist of PAHs but also include phenols and heterocyclic aromatics (i.e., carbazole or dibenzofuran). Coal tar is typically more dense than water (i.e., dense non-aqueous phase liquids [DNAPLs]). According to a former worker (Simonson 1997b), tar was a saleable product that was collected, stored in a tank on the south side of the Former Gas Works Property, and piped to barges at the Former Gas Works Dock. However, it is unlikely that all tar generated over the entire life span of the former gas works was recovered and sold in this manner.
- **Gas Liquor.** Gas liquor is water containing dissolved and suspended tar and oil constituents. , According to a 1942 report, gas liquor was reportedly discharged to the Port Washington Narrows through a drainpipe (Tymstra 1942).[4]
- **Ash, Clinker, and Slag (Mineral Residue of Fuel and Feedstocks) from Furnaces.** Ash is generally powdery, whereas clinker is partially fused, and slag is fused. These materials were reportedly placed on the bluff along the shoreline (Judd 2014) north of the Former Gas Works Property and may have also been deposited in the Former Ravine.[5]
- **Soot from Furnaces.** This material was reportedly placed in the Former Ravine near the oil storage tanks (Tymstra 1942).
- **Spent Scrubber and Purifier Media.** When scrubber and purifier media such as tar-soaked wood chips and shavings were saturated, they were removed and replaced. Spent scrubber media contains tar, and spent purifier media often contains tar, sulfide, and cyanide compounds removed during purification, including Prussian Blue (an iron-cyanide compound) (Hatheway 2012). During a period of gas works operations, tar-soaked wood chips and excelsior produced on-site were reportedly placed in the Former Ravine near the oil storage tanks (Tymstra 1942). However, an individual who worked at the former gas works between 1953 and 1955 indicated that the spent purifier media were hauled off-site (Simonson 1997b).

[4] It is suspected that the drain pipe referred to in the 1942 report corresponds to the former outfall that was removed and plugged as part of the 2010 TCRA (see Section 3.3.1).
[5] Boring logs for SP01 and MW04, which were located in the Former Ravine, indicate ash.

2.3.1.2 Post-1972 Operations on the McConkey Property

Operations on the McConkey Property after the former gas works discontinued operations have included activities by Lent's between approximately 1972 and 1982 and industrial park operations by others from approximately 1982 to the present.[6] Operations on the McConkey Property have included metal fabrication and sandblasting in the southern portion of the property and parking and equipment storage across the other portion of the property. Two buildings are located in the southern portion of the McConkey Property. Historical and current operations on the McConkey Property are shown on Figure 2-4. A generalized process flow diagram of the metal fabrication process is shown on Figure 2-5.

Ecology inspected industrial park operations on the McConkey Property in 1992, 1993, 1994, and 1995 and observed the following activities during that period that may have resulted in contaminant releases:

- Improper storage of sandblast grit, solvents, and paint sludge at a metal-fabricating shop; and

- Debris and drums containing oily substances scattered around the industrial park.

2.3.1.3 Operations on the Sesko Property

The Sesko Property was used for bulk petroleum storage and distribution from as early as 1946 to no later than 1993, when the aboveground storage tanks (ASTs) were removed. Lent's was the primary operator of the tank farm on the Sesko Property. Former AST locations are shown on Figure 2-4. A process flow diagram of petroleum storage and distribution operations is provided on Figure 2-5. After 1993, the Sesko Property was used for boat maintenance, automobile salvage, equipment and debris storage, parking, and metal reclamation. The owner of the Sesko Property was involved in legal disputes with the City over nonconforming use of the Sesko Property (as a junkyard), violations of the Shoreline Management Act, and, in 2003, improper decommissioning of an underground storage tank (UST). Ecology spill records also indicate that approximately 25 gallons of gasoline were released to surface water from the Sesko Property in January 2003. The majority of the equipment and debris has been removed, and the Sesko Property is currently vacant.

The Sesko Property includes remnants of the Former Ravine, which has been filled over the years. Fill activities have included the following:

- **Before 1930.** No records documenting fill activities before operation of the former gas works have been identified. However, based on a comparison of the 1919 shoreline (Figure 2-4) with an aerial photograph dated 1946 and sewer maps dated 1939, it appears that a portion of the Former Ravine was likely filled by the late 1930s, before construction of a historical residence located on the Sesko Property and before construction of the Lent's tank farm.

- **1931 to 1955.** Aerial photographs and recorded observations (Tymstra 1942; Judd 2014) indicate that the western portion of the Former Ravine was filled between

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[6] Based on City directory information, Lent's continued operating on the McConkey Property for at least 3 years after the McConkeys acquired the majority of the McConkey Property in 1979.

1931 and 1955. Recorded observations indicate that people unaffiliated with the former gas works dumped miscellaneous garbage, trash, and fill in the Former Ravine before 1942. Residual materials from former gas works operations (i.e., soot, ashes, cinders, and tar-laden wood chips and shavings) were also reportedly dumped in the Former Ravine during this period (see Section 2.3.1.1).

- **1941 to 1974.** An easement granted by Western to the City gave the City the right to dump refuse, garbage, and ashes from an incinerator into the Former Ravine. The easement reserved the right for Western to dump ashes and cinders in the easement area, which included the eastern 25 feet of the Former Gas Works Property (most of which lies on the current Sesko Property). According to the City, the historical records that partially document this time period were destroyed in a fire, and any documents regarding construction of the incinerator or dumping of refuse, garbage, or incinerator ash into the Former Ravine would have been lost in that fire.
- **1968.** A DNR inspection reported that concrete and piping debris were placed in the Former Ravine (DNR 1968).

Petroleum transfer lines that connected a dock located on the northern edge of the Sesko Property (Former Sesko Dock) to the Former ARCO Property and the Lent's tank farm were formerly located on the Sesko Property and may still be in place. An employee of the owner of the Sesko Property indicated that he had removed a portion of underground petroleum transfer piping he encountered in the northern portion of the Sesko Property. Petroleum transfer lines also reportedly connected the Former Sesko Dock to the Former SC Fuels Property to the east. Approximate pipeline locations, shown on Figure 2-4, were identified on construction plans for City sewer improvements (CH2MHill 1982; MH&A 1982).

2.3.2 Adjoining Properties

Surrounding properties include (1) the Penn Plaza Property, which is located to the south of the McConkey Property, (2) the Former ARCO Property, which is located to the west of the McConkey Property across Thompson Drive, and (3) the Former SC Fuels Property, which is located to the east of the Sesko Property across Pennsylvania Avenue (Figure 2-1). Historical and current operations on these properties are discussed in the following subsections.

2.3.2.1 Penn Plaza Property

There are five buildings on the Penn Plaza Property, which is used as an industrial park. Multiple tenants occupy the industrial park. Based on available records, the Penn Plaza Property has been used for commercial and/or industrial uses since the late 1930s or early 1940s. Prior to this time, an intermittent stream ran northeast across the Penn Plaza Property toward the Former Ravine on the current Sesko Property. This stream was reportedly used by area residents for dumping refuse and was filled in by 1942 (Judd 2014).

Operations on the Penn Plaza Property have included Lent's operations from the 1940s to approximately 1985 and industrial park operations from approximately 1985 to the present.[7] Lent's operations on the Penn Plaza Property included spray painting, metal plating, a pipe shop, truck repair, and parking for petroleum distribution.[8] A former employee of Cascade, who worked in Bremerton in 1968 and 1969, recalled that wood treating may also have occurred as part of Lent's operations (Clapp 1997). Since the cessation of Lent's operations, multiple tenants have used the Penn Plaza Property for industrial uses, including sheet metal fabrication, floating pier and acrylic septic tank manufacturing, concrete pipe/manhole manufacturing, heating and air conditioning repair, and marine propeller repair (TechLaw 2006; Hart Crowser 2007).

Ecology inspected operations at the Penn Plaza Property in 1992, 1993, 1994, and 1995 and identified the following activities that may have resulted in contaminant releases:

- A tenant reported to Ecology that an electroplating operation had made illegal discharges to a storm drain that resulted in a sewer backup.
- Ecology observed improper storage of waste concrete and waste oil at one of the tenant locations.
- Ecology observed diesel staining on the ground at another tenant location.
- Ecology observed debris and drums containing oily substances scattered around the industrial park.

On the north end of the Penn Plaza Property are oil and gasoline supply pipelines that connected the Former Sesko Dock with the Former ARCO Property to the west. The approximately location of these pipelines, based on a utility locate conducted during the time critical removal action (TCRA) in 2010, is shown on Figure 2-4.

2.3.2.2 Former ARCO Property

The Former ARCO Property was used for bulk petroleum storage and distribution from the mid-1940s to the late 1980s or early 1990s. Initially, 4 ASTs were present, with 2 added prior to 1956, 5 added in the late 1970s, and 4 added in the early 1980s for a total of 15 ASTs. Loading racks were located in the southeast corner of the Former ARCO Property. All tanks were removed by 1993. Property records indicate storage of gasoline, diesel, and oil. Product lines connected the ASTs on the Former ARCO Property with the Former Sesko Dock. Piping from the Former ARCO Property crossed the adjacent property to the north and ran west along the waterfront to a former dock (Former ARCO Dock) located approximately where the Port Washington Marina is today (see Section 2.3.3). According to a former resident, the piping to the Former ARCO Dock was located above ground (Judd 2014).

Since the early 1990s, the Former ARCO Property has been sporadically occupied by various tenants, including a tenant that conducted furniture refinishing and repair. The Former ARCO Property is currently being used for commercial purposes by Pipeworks Mechanical and Service, Inc.

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[7] Based on City directory information, Lent's continued operating on the McConkey Property for at least 3 years after the property was sold in 1979.

[8] Petroleum for Lent's petroleum distribution was stored on what is now the Sesko Property.

2.3.2.3 Former SC Fuels Property

The Former SC Fuels Property was used for bulk petroleum storage and distribution from the mid-1940s to the present. Operations on the Former SC Fuels Property are currently inactive. Initially, five ASTs were present, with one AST added prior to 1963, for a total of six ASTs. Four USTs were removed in 2003. Property records indicate storage of gasoline, diesel, and waste oil.

The Former SC Fuels Property is registered in Ecology's Voluntary Cleanup Program. A series of environmental investigations and remedial actions performed between 1997 and 2007 have confirmed releases of petroleum products and associated constituents, including gasoline, diesel, oil, BTEX, and PAHs. Additional information about the investigations and remedial actions is provided in Section 3.4.

Stormwater at the Former SC Fuels Property is collected in a series of catch basins, piped to an oil-water separator located at the top of the bluff, and discharged through an outfall to the Port Washington Narrows (Figure 2-4). Ecology conducted a Site visit in 2006 and noted a "gasoline odor" along the shoreline of the Former SC Fuels Property close to the stormwater outfall.

Pipes supplying petroleum to the Former SC Fuels Property tank farm ran from the Former SC Fuels Dock (see Section 2.3.3). An unknown number of petroleum transfer pipes also reportedly ran from the Former Sesko Dock to the tank farm on the Former SC Fuels Property, although their alignment is unknown (see Section 2.3.1.3).

2.3.3 Aquatic Parcels

Four docks were constructed in the aquatic parcels located adjacent (or closest to) to the properties described in Sections 2.3.1 and 2.3.2 (Figure 2-4). These aquatic parcels were leased from DNR. A description and brief history of each dock is included in the following subsections, and a detailed lease history prepared by DNR is provided in Appendix D.

2.3.3.1 Former Gas Works Dock

The Former Gas Works Dock was constructed by Western on November 25, 1930, as part of the development of the former gas works. It was located on the aquatic parcel adjacent and to the north of the Former Gas Works Property. The Former Gas Works Dock was used to offload coal, briquettes, and oil (via a 3-inch-diameter pipeline). Records indicate that the Former Gas Works Dock was also used to transfer heavy-end byproducts. In 1948, as part of the propane blending retrofit, the Former Gas Works Dock was updated to allow offloading of propane gas. Based on review of aerial photography, the Former Gas Works Dock was removed sometime between 1971 and 1974.

2.3.3.2 Former ARCO Dock

The Former ARCO Dock was constructed by the Richfield Oil Corporation in approximately 1942. It was located on the aquatic parcel immediately adjacent and to the west of the aquatic parcel operated by the former gas works. The Former ARCO Dock served as both boat moorage and support for the pipelines associated with upland ARCO operations. It was removed by Richfield Oil's successor in the mid-1980s.

2.3.3.3 Former Sesko Dock

The Former Sesko Dock was constructed by Lent's in approximately 1942. It was located on the aquatic parcel immediately adjacent and to the east of the aquatic parcel operated by the former gas works. The Former Sesko Dock was used to support supply pipelines for barge delivery of diesel and stove oil, which were stored on the Sesko Property. During the 1970s and 1980s, the Former Sesko Dock was also used to supply the tank farm on the Former ARCO Property and the tank farm on the Former SC Fuels Property. In 1993, the pipelines on the Former Sesko Dock were removed. The Former Sesko Dock was removed in September 2001 pursuant to a DNR order.

2.3.3.4 Former SC Fuels Dock

The Former SC Fuels Dock was constructed by General Petroleum Corporation of California in 1942. It was located on the aquatic parcel immediately adjacent and to the east of the aquatic parcel where the Former Sesko Dock was located. The Former SC Fuels Dock was constructed for the purpose of handling petroleum products. The Former SC Fuels Dock was removed in 1967 by Mobil Oil Corporation when barge deliveries of petroleum products were discontinued.

2.4 Environmental Setting

2.4.1 Climate and Meteorology

The Bremerton, Washington, area is dominated by a marine temperate climate with cool and comparatively dry summers and mild, wet, and cloudy winters (WRCC 2014). The average annual high temperature for Bremerton is 60 degrees Fahrenheit (°F), and the average annual low temperature is 43°F (WRCC 2014). Average annual precipitation is 52 inches, with nearly half of that occurring in November, December, and January (WRCC 2014). During this wet season, rainfall is usually light to moderate in intensity and continuous over a period of time, rather than brief, heavy downpours. During the driest months of July and August, it is not unusual for 2 to 4 weeks to pass with only a few showers (WRCC 2014). The prevailing wind direction in the region is south or southwest during the wet season and northwest in summer, with an average wind velocity of less than 10 miles per hour (WRCC 2014).

2.4.2 Topography and Drainage

The Former Gas Works Property is located on a bluff on the south shore of the Port Washington Narrows. The Former Gas Works Property generally slopes gently to the north and is covered with buildings or pavement. At the northern edge of the Former Gas Works Property, a vegetated bluff slopes steeply down to the beach. Over time, the bluff has expanded to the north with the placement of fill material. Remains of the Former Ravine along the eastern edge of the Former Gas Works Property can be seen as a cove located at the northern edge of the Sesko Property. Stormwater drainage characteristics on the Former Gas Works Property and adjacent properties are as follows:

- **McConkey and Penn Plaza Properties**. Pavement covers most of the McConkey and Penn Plaza Properties, and the properties have catch basins connected to the City stormwater drainage system. A City stormwater and combined sewer overflow (CSO) outfall is located offshore, north of Pennsylvania Avenue. A catch basin in the northwest corner of the McConkey Property is connected to an outfall on the beach below the bluff.

- **Sesko Property.** Most of the Sesko Property is unpaved. Stormwater either infiltrates or runs off, presumably to the north toward the Port Washington Narrows.

2.5 Geology and Hydrogeology

2.5.1 Regional Geologic Setting

The Site lies within the Puget Lowland, an area that has alternated between glacial and interglacial environments during the last 2 million years. The result has been a stacked and imperfectly preserved sequence of glacial and nonglacial strata. This irregular stratification has been further impacted by the tectonics of the Seattle fault, a regional thrust fault system that extends through the area, including a strand through Oyster Bay. The impacts of the fault system include uplift and tilting of bedrock and Quaternary strata in some areas and subsidence in others.

Interglacial climates produced sediments much like the forested Puget Lowland before extensive development, with broad floodplains and gently sloping uplands. These deposits include silty to sandy floodplain sediments, scattered gravelly channel deposits, and peat and lacustrine (lake) sediments. Glacial climates resulted in rapid accumulation of glacial sediments and scour of preexisting landforms and deposits. These deposits include advance glacial lake (glaciolacustrine) deposits, advance outwash (glacial river deposits), glacial till (subglacial deposits), and recessional glacial deposits.

Bedrock crops out on the northern end of the peninsulas between Phinney Bay and Ostrich Bay, and elsewhere generally north and west of the Site. Map data and limited deep well data suggest that bedrock generally dips to the south and west below the Site area. This bedrock dip forms a regional basement aquitard. Some of the older sediments above bedrock are also likely tipped in this direction due to regional rotation along the Seattle fault. Younger deposits, including those encountered in explorations for this project, are expected to be generally more horizontal but will include a number of discontinuous and irregularly shaped lenses of fine- and coarse-grained sediments that will impact the velocity and direction of groundwater flow. A conceptual geologic model of the Site area, including surficial geology (Figure 2-6) and subsurface geology (Cross Section AA–AA′ on Figure 2-7) has been developed using regional map and well log data. Areas below the known exploration depths are shown as “undifferentiated.”

The conceptual regional hydrogeologic model is one of rainfall and infiltration on an upland covered generally with till and glacial outwash. Some of this water runs off as stormwater, while a portion infiltrates. The water that infiltrates (groundwater) will migrate more quickly through more-permeable strata and will be generally retarded by less-permeable strata. The migration of water through these strata is influenced by the location and dip of the low-permeability strata (aquitards), as well as the location of waterways and other low-lying areas, which are often points of groundwater discharge. Regional patterns indicate that uplands are generally recharge areas, and slopes near sea level are discharge points. Groundwater also migrates from deeper strata and discharge upward into waterways.

2.5.2 Site Geology

Four principal geologic units have been identified based on previous explorations: fill, natural glacial deposits of the Vashon Drift, nonglacial deposits from one or more of the interglacial events that preceded the Vashon glaciation, and deposits from an older glaciation. The characteristics and distribution of these major sequences are described in this section, from the stratigraphic top (generally younger) to the bottom. Note that these geologic interpretations are based on logs prepared by multiple geologists over the course of the prior investigations. Subsurface interpretations from these earlier explorations (e.g., fill characteristics or extent) may be refined later based on future observations.

The locations of the cross sections are shown on Figure 2-8, and four geologic cross sections are provided on Figures 2-9 through 2-12. Soil boring logs are provided in Appendix E. A description of the soils observed at the Site is provided in the following text.

Although fill was not specifically identified in many of the soil boring logs, it was apparently present in the majority of the previous explorations at the Site, in thicknesses ranging from a foot or less to about 15 feet. The thickest fill is present in the Former Ravine area on the Sesko Property. Fill is generally composed of brown to black, loose to very dense, or stiff to very stiff variable mixtures of silt and sand with variable amounts of gravel, coal fragments, asphaltic concrete, and other debris. The density and consistency of the fill was generally high for nonstructurally placed fills and may be due to inclusion of ash in the fill soils, which can produce slight cementation of soils.

Over the majority of the Site, glacial deposits were encountered beneath the surficial fill. The geologic maps of the Site indicate the glacial unit is the Vashon Drift. The soils encountered in the explorations generally consisted of clean (fines are absent) to silty fine- to medium-grained sand with trace to minor amounts of gravel and scattered interbeds of sandy silt. These glacial deposits were observed to be dense to very dense and were generally brown to gray. The gradation and density of this unit suggests that it is primarily Vashon advance glacial outwash. This unit has moderate permeability and, where saturated, will form an aquifer.

Pre-Fraser nonglacial deposits (predating the Vashon Glaciation) are present in the bluffs and uplands in the northeastern portion of the Site. Explorations encountered olive to gray and brown, stiff to hard silt to sandy silt with interbeds of very dense silty sand. Thin interbeds or lenses of clay and silty clay and scattered gravelly layers may be present. This unit generally has low permeability; however, cleaner sandy layers may become saturated.

An older glacial sequence is present below the Vashon outwash and the pre-Fraser nonglacial deposits. The older glacial sequence consists of lenses or discontinuous layers of glacial till within an outwash-like brown to gray, very dense slightly silty to silty sand. The lenses of till are composed of brown to gray very dense silty gravel with sand and silty sand with gravel. The till lenses are generally considered an aquitard, but the outwash-like silty sand component was noted to be wet below about the 5 to 10 foot elevation, which probably reflects the regional water table. The scope of work for the RI, as described herein, will include additional investigations to determine whether the till acts as an aquitard at the Site.

2.5.3 Hydrogeology

Groundwater on the McConkey Property and Sesko Property was encountered at depths between 15 and 41 feet. Groundwater elevations have ranged between 3 and 10 feet above mean sea level, with an estimated flow direction to the north-northwest (to the Port Washington Narrows) during one sampling event (GeoEngineers, 2007b). Monitoring well construction details and groundwater elevation measurements are summarized in Table 2-1. Well construction logs are included in Appendix E.

Groundwater on the Former SC Fuels Property has been encountered at depths between 4 and 15 feet, with an estimated flow direction to the northwest. Groundwater on the Former SC Fuels Property appears to be perched within sandy zones present in generally low-permeability nonglacial soils.

The estimated directions of groundwater flow on the McConkey, Sesko, and Former SC Fuels Properties, based on previous studies, are shown on Figure 2-13. However, groundwater studies to date have not evaluated the effect of tidal influence on Site groundwater levels and flow direction. One-time groundwater elevation measurements are prone to error if tidal effects are significant.

2.6 Human Populations and Land Use

The Former Gas Works Property is located in Bremerton, which is the largest city on the Kitsap Peninsula and home to Puget Sound Naval Shipyard and the Bremerton Annex of Naval Kitsap Base. According to the 2010 census, the population of Bremerton is 37,729 people with 1,328 inhabitants per square mile. The racial makeup of Bremerton is predominantly white/Caucasian (74%) with the rest of the population classified as “other” or two or more races (10.4%), African American (6.7%), Asian (5.5%), Native American (2.0%), and Pacific Islander (1.3%). According to the 2000 census, the total population of the Suquamish Tribe is 616 people.

The Former Gas Works Property is in an area of industrial-zoned properties that includes the Former ARCO Property and Former SC Fuels Property. Surrounding this industrial property core are residential properties and a marina. A zoning map is included on Figure-2-1.

2.6.1 Tribal Use

Tribal commercial, subsistence, and ceremonial fisheries have historically occurred in Dyes Inlet and the Port Washington Narrows. The Tribe has stated that “Suquamish tribal members fully intend to continue to fish these areas for cultural, subsistence and commercial purposes” (Suquamish Tribe, 2014). According to the Tribe, it “uses the Washington Commercial Shellfish Growing Area Classification to determine the suitability of bivalve harvests (i.e., claims, oysters)” (Suquamish 2011). The marine area adjacent to the Former Gas Works Property is designated as “Unclassified” due to the proximity of CSOs, which precludes shellfish harvesting. However, according to the

Tribe, the harvest of finfish and other marine invertebrates (i.e., crab and sea cucumber) are not restricted adjacent to the Former Gas Works Property (Suquamish 2011).

2.6.2 Drinking Water Use

Water services at the Site and surrounding area are supplied by the City. The closest public water supply wells are located over one mile from the Site. The use of private wells within the Bremerton Water Service Area is not allowed, and there are no drinking water wells near the Site listed in Ecology's database.

The Site is located adjacent to the Port Washington Narrows, a saltwater body. The extent of saltwater intrusion and the potability of Site groundwater and its potential future use as a drinking water source will be evaluated as part of the RI.

2.7 Port Washington Narrows and Dyes Inlet

The Former Gas Works Property is located along the Port Washington Narrows, which is a tidal channel connecting Dyes Inlet to Sinclair Inlet and Puget Sound. Dyes Inlet is a terminal estuary, comprising five embayments (Phinney, Mud, Ostrich, Oyster, and Chico Bays) and the Port Washington Narrows (Figure 2-14).

The waters of Port Washington Narrows are relatively shallow, with average depths of less than 30 feet. Depths within Dyes Inlet range up to 100 feet but are typically less than 50 feet. Area bathymetry is shown on Figure 2-14.

The shorelines of the Port Washington Narrows and Dyes Inlet have been extensively developed. These shorelines include the cities of Bremerton and Silverdale as well as the community of Tracyton. Other significant features include several former U.S. Navy facilities and regional transportation networks, including State Routes 3 and 303. The Warren Avenue and Manette Bridges are located across the Port Washington Narrows east of the Former Gas Works Property.

Hydrologic inputs to the Port Washington Narrows and Dyes Inlet include the tidal exchange with Sinclair Inlet and freshwater inflows from both stream and piped flows. Information from Kitsap County and the City regarding identified stormwater outfalls, CSO discharge points, and surface water inputs is summarized on Figure 2-14. Additional private and municipal outfalls may be present in addition to those identified by these information sources.

Hydraulic exchange between Dyes Inlet, the Port Washington Narrows, and the balance of Puget Sound is limited by the geography and the resulting hydrodynamics. In addition to tide and current data available from public sources (e.g., National Oceanographic and Atmospheric Administration [NOAA]), the waters of Dyes Inlet and the Port Washington Narrows have been studied as part of regional water quality programs. Total maximum daily load studies and a contaminant mass balance evaluation have been performed for Dyes Inlet and may provide useful data for the RI/FS. Hydrodynamic modeling of the area has been performed as part of regional studies of Puget Sound. The results of additional studies are available to characterize environmental quality within Sinclair Inlet, immediately south of Dyes Inlet and the Port Washington Narrows. The Sinclair Inlet studies include extensive testing that has been performed in association with the Bremerton Naval Shipyard, as well as other regional study programs.

2.8 Natural Resources

This section describes the natural resources of the upland areas, aquatic habitats, and related data needs for the RI/FS.

2.8.1 Upland Areas

The upland areas of the Former Gas Works Property and surrounding areas have been developed for industrial uses consistent with zoning provisions. However, some terrestrial and riparian habitat is present, particularly on the bank adjacent to the Port Washington Narrows, the Former Ravine, and the shoreline areas of the McConkey and Sesko Properties. The Washington Department of Fish and Wildlife (WDFW) manages a Priority Habitats and Species Program (PHS). Preliminary queries of WDFW's PHS system did not identify any priority terrestrial natural resources on the parcels associated with the Former Gas Works Property

2.8.2 Aquatic Habitats

Aquatic habitats at the Site include those in the beach and subtidal areas within and near the Former Gas Works Property. Shoreline and aquatic habitat adjacent to the Former Gas Works Property are located within the Tribe's Usual and Accustomed area. Fish and shellfish resources are present within the waters of the Port Washington Narrows and Dyes Inlet. Fish and crab are known to be present and support commercial, recreational, and tribal fisheries. Shellfish harvesting within the Port Washington Narrows and Dyes Inlet has been restricted due to water-quality-related shellfish harvesting closures. However, efforts have been made by state and local governments, tribes, and other stakeholders to improve water quality in the area and reduce or lift these shellfish harvesting restrictions. A number of shellfish enhancement projects have been proposed within portions of Dyes Inlet. It is not known what measures have been undertaken by the Washington State Department of Health or the Kitsap Public Health District (KPHD) to monitor illicit shellfish harvesting within Dyes Inlet or the intertidal areas adjacent to the Site. Signage indicating the closure of the beach adjacent to the Former Gas Works Property was installed as part of the 2013 TCRA (see Section 3.3.2).

The query of the WDFW PHS identified two aquatic natural resources in the vicinity of the Former Gas Works Property: estuarine intertidal aquatic habitat along the northern and southern shorelines of the Port Washington Narrows and hardshell clams along the northern shoreline of the Port Washington Narrows.

2.9 Cultural Resources

There are no recorded archaeological sites or historic structures at the Former Gas Works Property or in the immediate vicinity. However, no cultural resources surveys have been conducted on the Site or in the vicinity prior to the present project. The documented archaeological sites nearest to the Former Gas Works Property include the following:

- (b)(3)
-

(b)(3)

Kitsap County assessor's records (accessed January 2014) indicate that there is one building older than 50 years on the Penn Plaza Property—a warehouse constructed in 1955. The structure has not been evaluated for National Register of Historic Places (NRHP) eligibility. No impacts on this structure are anticipated during the RI/FS.

An archaeologist from Anchor QEA, LLC (Anchor) visited the project area in August 2013 to make a preliminary assessment of current conditions. The project area has been extensively modified in the historic and modern eras, with placement of fill materials and debris, and development and redevelopment of the Site for industrial uses. No native sediments, other than active beach deposits, were visible in the project area.

3 Initial Evaluation

This section summarizes the regulatory requirements and existing data that supported the development of the preliminary conceptual site model (CSM), which is described in detail in Section 4.

3.1 Regulatory Requirements

This section identifies initial applicable or relevant and appropriate requirements (ARARs), preliminary remediation goals (PRGs), and remedial action objectives (RAOs) for the purposes of project planning. Potential ARARs were identified to facilitate communications with support agencies, help plan potential field activities, and assist in the identification of RAOs and PRGs. Initial PRGs were identified to help evaluate existing data and assist in the selection of appropriate analytical methods. The ARARs, PRGs, and RAOs will be further developed during the RI/FS process. Those ARARs, PRGs, and RAOs that are determined to be applicable to the Site-related decisions may include some, none, or all of those identified in this section. The ARARs, PRGs, and RAOs that are ultimately determined to be applicable to the Site-related decisions will be established in consultation and coordination with key stakeholders and the public during the RI/FS process.

3.1.1 Applicable or Relevant and Appropriate Requirements

The project must comply with CERCLA Section 121, which requires remedial actions to achieve ARARs. According to the National Contingency Plan (Code of Federal Regulations, Title 40, Section 300.5 [40 CFR 300.5]), applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental and facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance identified at a CERCLA site. Appropriate and relevant requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that are not applicable to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances at a CERCLA site, but address problems or situations similar to those encountered at the site that their use is well suited to the particular CERCLA site.

Some federal, state, and local environmental and health agencies may develop criteria, advisories, guidance documents, and proposed standards that are not legally enforceable but contain useful information for selecting cleanup levels or implementing a cleanup remedy. These fall into the category of "to be considered" (TBC) elements. TBCs are not mandatory requirements but may complement the identified ARARs.

ARARs and TBCs potentially relevant to the RI/FS are presented in Tables 3-1 through 3-3 and organized into the following categories:

- Contaminant-specific requirements;
- Location-specific requirements; and

- Performance, design, or other action-specific requirements.

Some ARARs fit neatly into a single category, whereas others may fall into more than one category. The categories are described as follows:

- Contaminant-specific ARARs are laws and requirements that establish health- or risk-based numerical values or methodologies for developing such values (EPA 1988b). These ARARs are used to establish the acceptable concentration of a contaminant that may remain in or be discharged to the environment. As such, contaminant-specific ARARs are considered in identifying the PRGs. Contaminant-specific ARARs are listed in Table 3-1.
- Location-specific ARARs are requirements that are triggered on the basis of the location of the remedial action to be undertaken (EPA 1988b). Location-specific ARARs may restrict or preclude certain remedial actions or may apply only to certain portions of the Site. Some location-specific ARARs overlap action-specific ARARs. Location-specific ARARs are listed in Table 3-2.
- Action-specific ARARs are performance, design, or other requirements that may place controls or restrictions on a particular remedial action (EPA 1988b). Action-specific ARARs are typically technology- or activity-based requirements or limitations on actions, and these requirements may include contaminant-specific standards or criteria that must be met as the result of an action. For remedial actions at the Site, these requirements are not necessarily triggered by the presence of specific contaminants in Site media, but rather by the specific actions that occur at the Site. Action-specific ARARs are listed in Table 3-3.

3.1.2 Preliminary Remediation Goals

This section identifies PRGs for the initial screening of existing soil, groundwater, and sediment data. Surface water initial PRGs have been identified to assist in the development of the RI/FS Work Plan; however, no surface water data are available for the Site. The initial PRGs were used in the development of the SQAPPs (Appendices A and B) to select appropriate analytical methods.

Potential PRGs include numerical values identified in ARARs, peer-reviewed risk-based values, or values identified in other screening benchmark sources. Potential PRGs include values from the following sources:

1. **ARARs:**
    - Soil: none available (except for those related to polychlorinated biphenyls (PCBs) in the Toxic Substances Control Act);
    - Groundwater: maximum contaminant levels (MCLs);
    - Surface water: national recommended water quality criteria for human health (organisms only) and aquatic life (chronic value); and
    - Sediment: Washington State Sediment Management Standards (SMS).
2. **Peer-reviewed sources:**

- Soil: EPA human health regional screening levels (RSLs) and EPA ecological soil screening levels (EcoSSLs);
- Groundwater: EPA human health RSLs;
- Surface water: none available; and
- Sediment: NOAA effect range-low (ER-L) and effect-range-medium (ER-M) benchmarks (Long et al., 1995).

3. **Other screening benchmark sources:**

- Soil: EPA Region 5 Resource Conservation and Recovery Act (RCRA) EcoSSLs
- Groundwater: none available;
- Surface water: EPA Region 3 Biological Technical Assistance Group (BTAG) ecological surface water screening benchmarks and EPA Region 5 RCRA ecological surface water screening levels; and
- Sediment: EPA Region 3 BTAG ecological sediment screening benchmarks and EPA Region 5 RCRA ecological sediment screening levels.

Tables 3-4, 3-5, 3-6, and 3-7 summarize the potential PRGs from these sources for each medium (soil, groundwater, sediment, and surface water, respectively) and identify an initial PRG for each contaminant. The initial PRG for a given contaminant was selected as the lowest of the ARARs or peer-reviewed risk-based criteria. If a value from these first two sources is unavailable, the initial PRG was selected as the lowest value in the “other screening benchmark” category. For sediment, the regionally specific SMS value was used. If no SMS value exists for the contaminant, the peer-reviewed NOAA value was used.

For soil, two different initial PRGs were identified: one for surface soil (which includes a consideration of screening levels for terrestrial ecological receptors) and one for subsurface soil at depths below potential ecological exposures. The initial PRGs include the following:

- Soil:
  - EPA RSLs – residential
  - EPA RSLs – industrial
  - EPA EcoSSLs – birds
  - EPA EcoSSLs – mammals
  - EPA EcoSSLs – invertebrates
  - EPA EcoSSLs – plants
  - EPA Region 5 RCRA EcoSSLs
- Groundwater:
  - EPA MCLs
  - EPA RSLs – tap water

- Sediment:
    - Washington State SMS sediment cleanup objectives (SCOs);
    - NOAA ER-L benchmarks (Long et al. 1995);
    - EPA Region 3 BTAG ecological marine sediment screening benchmarks; and
    - EPA Region 5 RCRA ecological sediment screening benchmarks.
- Surface water:
    - National recommended water quality criteria for aquatic life (EPA, 2013b);
    - EPA Region 3 BTAG ecological marine surface water screening benchmarks; and
    - EPA Region 5 RCRA ecological surface water screening levels.

3.1.3 Remedial Action Objectives

RAOs consist of goals for protecting human health and the environment that are specific for each potentially contaminated environmental medium (e.g., soil, groundwater, and sediment). RAOs for protection of human receptors typically include both a contaminant level and an exposure route. RAOs for protection of environmental receptors typically seek to preserve or restore a resource and are typically expressed in terms of the medium of interest and target cleanup levels. The preliminary RAOs related to the protection of human health are as follows:

- **Groundwater.** Reduce risk to human health from direct contact with, and consumption of, groundwater contaminated with Site-related contaminants of concern (COCs) to protective levels.
- **Sediment.** Reduce risk to human health from consumption of fish and shellfish containing Site-related COCs to protective levels.
- **Sediment.** Reduce to risk to human health from incidental ingestion and/or dermal exposure to Site-related COCs during potential recreational use of the beach areas at the Site to protective levels.
- **Vapor.** Reduce risk to human health from inhalation of vapors from groundwater and/or soils contaminated with Site-related COCs to protective levels.
- **Soils (Surface and Subsurface).** Reduce risk to human health from direct contact with or incidental ingestion of Site-related COCs to protective levels.

The preliminary RAOs related to environmental protection are as follows:

- **Groundwater.** Reduce, to protective levels, risks to ecological receptors from direct contact with and consumption of groundwater contaminated with Site-related COCs, including indirect exposure from consumption of prey exposed to groundwater entering the Port Washington Narrows.

- **Upland Soil.** Reduce, to protective levels, risks to terrestrial wildlife exposed to Site-related COCs through direct contact with and incidental ingestion of Site soil or consumption of soil-dwelling invertebrates.
- **Sediment.** Reduce, to protective levels, risks to aquatic wildlife from exposure to Site-related COCs in surface sediments or in prey species at the Site.
- **Sediment.** Reduce, to protective levels, risks to the benthos from Site-related COCs in surface sediments.

The preliminary RAOs will be developed further throughout the RI/FS process, in consultation with key stakeholders and the public, and may be revised, refined, or replaced.

3.2 Previous Site Investigations

Previous environmental field investigations at the Former Gas Works Property include the following:

- Sesko Property Field Inspection (Ecology 1995);
- Preliminary Upland Assessment, McConkey and Sesko Properties (GeoEngineers 2007b); and
- Targeted Brownfields Assessment (TBA), McConkey and Sesko Properties (E&E 2009).

The upland exploration locations and sampling depths by analyte group are provided on Figure 3-1. The scope and general conclusions of each study are described in the following subsections.

3.2.1 Ecology Field Inspection (1995)

In 1995, Ecology collected three surface soil samples from the Sesko Property and one surface sediment sample from the tidelands just north of the Sesko Property. The samples were analyzed for metals and SVOCs. High concentrations of PAHs were detected. Ecology used the data in conducting a Site Hazard Assessment and gave the Site a ranking of “1” (highest concern).

3.2.2 Preliminary Upland Assessment (2007)

In 2007, on behalf of the City and funded by a brownfield grant from EPA, GeoEngineers conducted a preliminary assessment of the McConkey and Sesko Properties (GeoEngineers 2007a) that included the following:

- Advancing eight soil borings and collecting soil samples to a maximum depth of 45 feet;
- Installing monitoring wells at each of the eight soil boring locations and collecting groundwater samples; and

- Analyzing soil and groundwater samples for total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), SVOCs, PCBs, and metals.

This work identified relatively high concentrations of gasoline- and diesel-range TPH, VOCs including benzene, and PAHs in soil and groundwater on the McConkey and Sesko Properties. VOCs and PAHs were detected in soil samples at depths up to 35 feet. Several metals, including arsenic, lead, and chromium (including chromium VI), were detected in groundwater at concentrations greater than the potential drinking water cleanup standards.

3.2.3 Targeted Brownfield Assessment (2008)

In 2008, on behalf of EPA, Ecology & Environment, Inc. (E&E) conducted a TBA of the McConkey and Sesko Properties (E&E 2008) that included the following:

- Advancing seven soil borings and collecting soil samples to a maximum depth of 45 feet;
- Installing monitoring wells at two of the seven boring locations;
- Collecting groundwater samples from the two wells and from temporary screens placed at four of the seven soil boring locations;
- Collecting five surface sediment samples from the beach north of the properties;
- Analyzing soil, groundwater, and sediment samples for TPH, VOCs, SVOCs, and metals.

Similar to the Preliminary Upland Assessment, this work identified relatively high concentrations of gasoline- and diesel-range TPH, VOCs including benzene, and PAHs in soil and groundwater on the McConkey and Sesko Properties. The assessment also identified relatively high concentrations of PAHs in surface sediments. VOCs and PAHs were detected in soil samples at depths up to 45 feet.

3.3 Previous Site Removal Actions

Two TCRAs have been performed at the Site as described in this section.

3.3.1 Time Critical Removal Action (2010)

In August 2010, sheens on the surface water of the Port Washington Narrows were reported to KPHD. Upon further investigation, KPHD identified a 12-inch-diameter concrete pipe that appeared to be the source of the sheen. The pipe is believed to be an abandoned City CSO outfall. KPHD reported the release to EPA, which in turn notified the U.S. Coast Guard (USCG) for a response because the pipe was within its jurisdiction. In 2010, at the request of EPA, E&E conducted sampling and analysis as part of the EPA and USCG's initial response. The response sampling included the collection of 32 surface sediment samples from a depth of 0 to 6 inches. The sediment samples were analyzed for VOCs and SVOCs, both of which were detected.

EPA, DNR, KPHD, and Ecology entered into a USCG-led coordinated response under a Unified Command Structure. Cascade became aware of the response in October of 2010 and informed the USCG that it was interested in contributing to the response. USCG subsequently added Cascade to the Unified Command Structure and issued Cascade an Administrative Order for a Pollution Incident (Order) to implement response actions at the Site under the oversight of USCG. Cascade accepted the Order in a letter dated October 29, 2010.

In response to the Order, Cascade developed an Incident Action and TCRA Work Plan (Anchor QEA and Aspect 2010), which outlined the scope and details of the 2010 TCRA. The 2010 TCRA included the following key elements:

- Investigation of the location and orientation of the abandoned pipe;
- Permanent plugging of the pipe as close as practicable to the shoreline;
- Removal of all portions of the pipe from the new plug to the terminus of the pipe;
- Backfilling of the excavation created by removal of the pipe with clean beach material;
- Placement of an organoclay mat over impacted sediments (with minimal disturbance) near the terminus of the pipe that were observed to generate sheen; and
- Continued maintenance of a containment system until field observations and inspections confirm that the situation is stable (no sheen).

On November 5, 2010, USCG and the other members of the Unified Command Structure approved the Incident Action and TCRA Work Plan. Cascade commenced the 2010 TCRA immediately upon approval and completed the 2010 TCRA on November 8, 2010 (Anchor QEA 2011). The removal action satisfied the following objectives of the Incident Action and TCRA Work Plan:

- The pipe was located and traced to the shoreline.
- The pipe was plugged as close as practicable to the shoreline, at the location specified in the Incident Action and TCRA Work Plan.
- All pipe sections downgradient of the new plug were removed together with all overburden sediments.
- All excavations were filled to grade with clean beach material.
- The organoclay mat was placed over the area of impacted sediments specified in the Incident Action and TCRA Work Plan.

Inspections of the 2010 TCRA area were completed as specified in the Incident Action and TCRA Work Plan. No surficial sheens related to the 2010 TCRA have been observed to date. The constructed elements of the 2010 TCRA are shown on Figure 3-2.

3.3.2 Time Critical Removal Action (2013)

In 2013, Cascade completed a removal evaluation pursuant to the requirements of the AOC and the EPA-approved Removal Evaluation Work Plan (Anchor QEA and Aspect 2013a). The objective of the removal evaluation was to assess whether suspected migration pathways at the Site pose a threat to human health, welfare, or the environment if left unaddressed before completion of the RI/FS. The results of the removal evaluation were reported in the EPA-approved Removal Evaluation Report (Anchor QEA and Aspect 2013c). The removal evaluation identified the following conditions that warranted action before completion of the RI/FS:

- **Stormwater intrusion into Manhole A.** Manhole A was believed to remain connected to the 12-inch-diameter concrete pipe that was plugged as part of the 2010 TCRA. Based on inspections conducted as part of the removal evaluation, it was determined that stormwater could have been entering Manhole A through surface runoff or via a piping connection to Manhole A from a nearby sump. Stormwater entering Manhole A posed a risk of hydraulically surcharging the pipe plugged during the 2010 TCRA, which in turn could have increased the risk of a hazardous substances release to the Port Washington Narrows.
- **Hydrocarbon sheen and deposits of solid hydrocarbon material in SG-04/SG-05 Area.** Hydrocarbon sheens were observed in shallow subsurface sediments in the western area of the beach, near sampling stations SG-04 and SG-05. Surficial solid hydrocarbon material was also observed in the SG-04/SG-05 area. Both the sediments containing hydrocarbon sheen and the solid hydrocarbon material contained concentrations of PAH compounds that were elevated in comparison to those of the surrounding beach sediments.

The Removal Evaluation Report proposed the following removal actions in response to the identified conditions:

- **Plugging the connections to Manhole A.** This action was intended to minimize the risk of hydraulic surcharge to the pipe plug, thereby minimizing the risk of hydrocarbon releases from the pipe.
- **Remove the accessible solid hydrocarbon material and place a cap over sediments containing hydrocarbon sheen in SG-04/SG-05 area.** These actions were intended to minimize the risk of additional releases of hydrocarbons from this area to surface waters of the Port Washington Narrows and to prevent direct contact with these materials by beach users.
- **Install signage.** The purpose of the signs is to warn beach users about the presence of hydrocarbon contaminants in the beach sediments and provide agency contact information regarding the Site and the ongoing RI/FS process.

Upon completion of the removal evaluation, Cascade prepared a work plan describing the proposed removal actions in more detail. EPA approved the Final Removal Action Work Plan (Anchor QEA and Aspect 2013b) and directed Cascade to perform the proposed removal actions (EPA 2013c). After EPA's approval, Cascade implemented the removal action (2013 TCRA), which met all of the objectives specified in the Final Removal Action Work Plan including the following:

- Removing solid hydrocarbon material identified in the western beach area;
- Installing an organoclay mat and cover over the hydrocarbon sheen in subsurface sediments in the western beach area;
- Plugging Manhole A and the sump drain from the tank containment area;

- Completing beach monitoring inspections to confirm the effectiveness of the 2013 TCRA. Quarterly monitoring inspections are ongoing; and
- Installing required signage.

The work was completed in general accordance with the Final Removal Action Work Plan and documented in the TCRA Removal Action Report (Anchor QEA and Aspect 2014). Three modifications to the scope of work specified in the Final Removal Action Work Plan were made with EPA approval based on the observed conditions:

- The organoclay mat and cover in the northeastern portion of the designed mat and cover area was extended to cover sediments exposed by the removal of the solid hydrocarbon material from the intertidal area.
- Manhole A was plugged by means of a concrete ring extending above the ground surface and capped with a bolted steel cover.
- Consistent with approvals from the City and pursuant to an access agreement with Penn Plaza Storage, LLC, a catch basin draining into the tank containment area was rerouted to a City storm drain line to prevent accumulation of stormwater in the containment area.

The constructed elements of the 2013 TCRA are shown in Figure 3-2.

3.4 Other Upland Investigations and Remedial Actions

Investigations and remedial actions conducted at other locations in the immediate vicinity of the Site may be relevant to characterizing the Site or understanding areawide conditions. The only known upland investigations or remedial action performed in the immediate vicinity of the Site are those conducted at the Former SC Fuels Property.

Between 1997 and 2007, various consultants performed soil and groundwater sampling at the Former SC Fuels Property (Pacific Environmental 1997; Noll 1999 and 2000; GeoEngineers 2002 and 2003; and GeoScience Management 2007), including the following:

- Advancing 13 hand-auger borings, 18 direct-push soil borings, and 15 hollow-stem-auger borings to a maximum depth of 22 feet;
- Installing 15 monitoring wells to a maximum depth of 20 feet;
- Collecting 12 soil confirmation samples during removal of four USTs; and
- Analyzing soil and groundwater samples for TPH, BTEX, and/or lead.

The investigations indicated the presence of TPH and BTEX in soil and groundwater on the Former SC Fuels Property and in the eastern portion of the Pennsylvania Avenue right-of-way. The TPH and BTEX concentrations exceeded Washington State Model Toxics Control Act (MTCA) Method A cleanup levels.

3.5 Other Sediment Investigations and Remedial Actions

In addition to the sediment data developed as part of previous investigations and remedial actions at the Site, other data sets have been compiled. The studies completed within the

Port Washington Narrows and Dyes Inlet may provide information relevant to the RI/FS. Studies identified to date for these areas include the following:

- Chemical testing of sediments:
    - 2008 and 2009 Puget Sound Assessment and Monitoring Program (PSAMP) Spatial/Temporal Monitoring, Central Sound (PSAMP 2005 and 2009);
    - 1989 to 2013 PSAMP Long-Term/Temporal Monitoring (PSAMP 2005 and 2011a);
    - 2009 PSAMP Urban Waters Initiative, Bainbridge Basin (PSAMP 2005, 2009, and 2011b); and
    - Ocean Survey Vessel *Bold* Summer 2008 Survey (USACE et al. 2009).
- Chemical testing of fish or shellfish tissue:
    - 2010 and 2012 Environmental Investment Project (ENVVEST) (Johnston et al. 2010; Brandenberger et al. 2012);
    - 2005 and 2007 NOAA Mussel Watch at station SIWP (Lauenstein and Cantillo 1993; Kimbrough and Lauenstein 2006; Kimbrough et al. 2006; and Kimbrough et al. 2008); and
    - 2001 303d Ecology clam and crab sampling data (Ecology 2002).
- Studies of surface water quality:
    - An Integrated Watershed and Receiving Water Model for Fecal Coliform Fate and Transport in Sinclair and Dyes Inlets, Puget Sound, Washington (Johnston et al. 2009); and
    - Sinclair and Dyes Inlets Fecal Coliform Total Maximum Daily Load: TMDL and Water Quality Implementation Plan (Lawrence et al. 2012).
- Regional studies of contaminant source inputs to these water bodies:
    - Contaminant Mass Balance for Sinclair and Dyes Inlets, Puget Sound, Washington (Crecelius et al. 2003).

Evaluation of this sediment and tissue data is discussed further in Section 3.9.

3.6 Existing Data and Data Usability

The existing Site characterization data have been reviewed in terms of data usability for the RI/FS. The existing data include data for the Former Gas Works Property and also data for sediments and tissue within the Port Washington Narrows, Dyes Inlet, and nearby portions of Puget Sound.

Data quality review included the definition of minimum data acceptability criteria (MDAC). Relevant guidance was applied, including the following:

- EPA (1988a) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA;
- EPA (1992) Guidance for Data Useability in Risk Assessment, Part A;

- EPA Contract Laboratory Program Functional Guidelines for Data Review (variable dates for different analyte groups); and
- EPA (2009) Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use.

3.6.1 Minimum Data Acceptability Criteria

The MDAC evaluations of historical soil, groundwater, and sediment investigations are described for each sampling event in Table 3-8.[9] MDAC evaluations of existing sediment and tissue investigations are described in Table 3-9. This MDAC review considered the following criteria:

- Work Plan Documentation:
  - Documentation describing the sampling program or event, the methods used, and the parties involved in sample collection must be available.
  - Collection methods must be clearly defined and be adequate for obtaining representative and quantitative information.
  - The purpose of data collection should be available.
- Sample Location and Collection Methods:
  - Sample coordinates and a qualitative understanding of accuracy (i.e., knowledge of how the location was established or the method by which the coordinates were obtained) must be documented. The coordinate system must be documented.
  - Sample collection method and matrix must be documented. For example, a water sample must be identified as to whether it is a surface water, porewater, or groundwater sample and whether it is whole water or filtered (i.e., total versus dissolved fraction). Temporal or spatial compositing and sample volume must be identified. For tissue samples, tissue preparation must be documented.
  - Sample depths and, where applicable, start and end depths must be identified.
  - Sample storage methods must be documented and consistent with approved methods, including holding time and preservation.
  - Sample chain of custody must be documented.
- Laboratory Analysis:
  - Data tables are available (not in summary format) with laboratory reports and data validation information.

[9] Investigations conducted under the Order for the Site and performed in accordance with EPA-approved Quality Assurance Project Plans (i.e., the 2013 TCRA) are not included in the MDAC tables.

- Appropriate detection limits and quantitation limits are achieved so that the data meet the RI data quality objectives (DQOs) for environmental investigations:
  - Detection limits, units for each detection limit, and data qualifiers must be reported. Nondetected results must have the associated detection or reporting limits indicated. Data qualifiers must follow EPA guidance or be defined in documentation.
  - Analytical methods must be documented and acceptable based on EPA guidance.
  - Measurement instruments and calibration procedures must be documented.
  - Toxicity and bioaccumulation test methods must be documented, including any deviations from standard protocols. For risk assessment, test methods must follow standard protocols, including controls and reference tests. Proper documentation to assess methods and statistical treatment must be available. Where possible, statistical results should be recalculated from the raw test data.
  - Taxonomic data must be reported to the lowest practicable taxonomic level on a sample-specific basis, with scientific nomenclature. Taxonomic levels must be sufficient to assess relevant metrics for ecological risk assessment (ERA), such as feeding guilds or stress-induced compositional changes in the community.
  - Collection methods, sample preservation, and sample preparation methods must be documented.
  - Biological community metric calculations must be defined and documented.

- Quality Control and Data Validation:
  - Documentation of field and laboratory quality control samples (duplicates and blanks) must be present.
  - Analytical chemical data must have been validated and qualified consistent with EPA functional guidelines or EPA Region 10 validation practices.
  - Hard copies of laboratory data reports (e.g., Form 1 or Certificates of Analysis) must be available to verify that electronic or tabulated data were accurately transcribed or transmitted.

3.6.2 Data Usability

Based on the results of the MDAC evaluation and considering the data representativeness for current Site conditions, the data were classified in one of the following data usability (DU) categories:

- **DU-1.** These data meet most or all of the MDAC requirements and are considered reasonably representative of Site conditions. DU-1 data are used in this Work Plan for COPC and source identification and preliminary evaluations of the nature and extent of contamination.
- **DU-2.** These data meet most of the MDAC requirements but have been superseded by more current or higher quality data for representation of the nature and extent of contamination. DU-2 data are used in this Work Plan for COPC and source identification.
- **DU-R.** These data do not meet the MDAC requirements and are not used in this Work Plan.

Of the existing data, the data were classified as follows:

- DU-1:
  - All data collected during the 2013 TCRA.
  - Soil data, sediment data for analytes other than PAHs, and groundwater data from monitoring wells, collected during the 2008 TBA.
  - Soil and groundwater data collected during the 2007 Preliminary Upland Assessment. These data met most of the MDAC criteria but underwent minimal data validation.
  - Regional sediment monitoring data collected under the following programs:
    - 2008 and 2009 PSAMP Spatial/Temporal Monitoring, Central Sound
    - 1989 to 2013 PSAMP Long-Term/Temporal Monitoring
    - 2009 PSAMP Urban Waters Initiative, Bainbridge Basin
    - Ocean Survey Vessel Bold Summer 2008 Survey
  - 2010 and 2012 ENVVEST mussel data
  - 2005 and 2007 NOAA Mussel Watch at station SIWP
  - 2001 303d Ecology clam and crab sampling data
- DU-2:
  - Sediment data collected during the 2010 TCRA and sediment data for PAHs collected during the 2008 TBA. These data met most of the MDAC criteria but have been superseded by more recent data collected in 2013, after the 2010 TCRA was completed.
- DU-R:
  - Soil and sediment data collected during the 1995 Ecology Field Inspection. These data had limited documentation, including poorly documented sampling locations, no documentation of collection or sample handling methods, and no chain of custody.

- Groundwater data collected from temporary borings during the 2008 TBA. The samples were not filtered, and the data are not considered representative of groundwater conditions because of potential bias due to sample turbidity.

3.7 Existing Data Summary

This section summarizes existing relevant data for soil, groundwater, and sediment. The data have been used to prepare the preliminary CSM (Section 4) to support the definition of the Initial Study Area (see Section 6.1) and to develop the scope of work for the RI. The existing data will be used in the RI to help assess the nature and extent of contamination. They include data from the 2007 Preliminary Upland Assessment, select data from the 2008 TBA, and data from the 2013 TCRA. Data classified as DU-1 (see Section 3.6) are included in the tables and figures associated with this section. Data summary tables for each medium that include all data classified as DU-1 or DU-2 are provided in Appendix F.

3.7.1 Soil Data

Soil samples were collected as part of the investigations conducted in 2007, 2008, and 2013. The soil samples were collected and analyzed for TPH, metals, SVOCs (including PAHs), VOCs, and PCBs. Table 3-10 summarizes the number of samples collected for analysis of each constituent and an evaluation of detected concentrations as compared to the initial PRG. Data for metals are also compared to natural background concentrations. The soil analytical data are summarized in tables provided in Appendix F.

The constituents detected in soil at concentrations above the initial PRGs include the following:

- VOCs, including benzene, ethylbenzene, cis-1,3-dichloropropene, and trans-1,3-dichloropropene;
- PAHs; and
- Metals, including antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel, thallium, vanadium, and zinc.

Other than PAHs, no SVOCs were detected at concentrations above the initial PRGs; however, the reporting limits for a subset of SVOCs exceed the initial PRGs at some locations (Table 3-10 and Appendix F). Practical quantitation limits (PQLs) for COPCs based on standard analytical methods are provided in Table 3-10 for comparison.

PCBs were not detected in soil; the reporting limits for PCBs in all samples were less than the initial PRGs (Appendix F).

Initial PRGs are not identified for TPH, which is not a hazardous substance under CERCLA. However, identifying the nature and extent of different TPH products (e.g., gasoline or diesel) may be helpful in defining contaminant sources. TPH data should be used with caution at sites, such as MGP sites, where non-petroleum hydrocarbon mixtures are present (e.g., coal tar). Therefore, an understanding of the type of product present, as assessed by sample chromatogram review or forensic analysis and interpretation, is needed to correctly interpret TPH data. For the purposes of this Work Plan, TPH distribution was not evaluated but will be evaluated in the RI.

A summary of VOCs, PAHs, and metals detected at concentrations above the initial PRGs is provided in the following subsections by analyte group. The maximum concentration detected at each boring location and a comparison to the initial PRGs and/or natural background concentrations in surface and subsurface soil is provided for the primary constituents detected at concentrations greater than the initial PRGs[10] (Figures 3-3 through 3-14). As described in Section 3.1.2, initial PRGs for surface soil include a consideration of potential terrestrial ecological exposure, whereas the initial PRGs for subsurface soil do not. For the purposes of this Work Plan, surface soil is defined as soils from 0 to 10 feet in depth, and subsurface soil is defined as soils 10 feet in depth or greater.

3.7.1.1 Volatile Organic Compounds

Two BTEX compounds, benzene and ethylbenzene, were detected at concentrations greater than the initial PRGs. The most frequent detections of benzene above the initial PRG occurred at two locations: in surface soil collected at sample location MW-3, in the vicinity of the former finished gas storage tanks, and at sample location SP03, near the edge of the Former Ravine fill area (Figure 3-3). Benzene was not detected in any subsurface soil samples at a concentration above the initial PRG (Figure 3-4). BTEX compounds are potentially an indicator of MGP-related releases but may result from other sources (e.g., gasoline-range TPH or industrial solvents).

Two halogenated VOCs, cis-1,3-dichloropropene and trans-1,3-dichloropropene, were detected at concentrations above the initial PRG in one sample. The source of these VOCs is unknown.

3.7.1.2 Polycyclic Aromatic Hydrocarbons

The maximum concentrations of naphthalene in surface and subsurface soil are shown on Figures 3-5 and 3-6, respectively. The concentrations of total carcinogenic PAHs (cPAHs)[11] in surface and subsurface soil are shown on Figures 3-7 and 3-8, respectively. The vertical distribution of naphthalene concentrations in soil is illustrated along geologic cross sections A–A′, B–B′, C–C′, and D–D′ in Figures 2-9 through 2-12, respectively.

The concentrations of total cPAHs and naphthalene exceeding the initial PRGs were detected at sampling locations that correspond to operational areas of the former gas works. In surface soil, the highest concentrations of both total cPAHs and naphthalene were detected at sample location MW-3, advanced in the vicinity of the storage tanks, which held light oil and coal tar (Simonson 1997b). Likewise, the highest concentrations of both total cPAHs and naphthalene in subsurface soil were detected at sample location MW-6, which was advanced at the location of the former gas holder.

Generally, concentrations of naphthalene and cPAHs on the Former Gas Works Property are highest in surface soil and decrease with depth (MW-3 and SP03, for example). However, at MW-6, advanced at the location of the former gas holder, PAH concentrations detected in subsurface soil were much higher than those in surface soil. Because the gas holder was reportedly at least 10 feet deep, this finding may indicate that the gas holder was filled with cleaner soil after it was demolished. Also, the concentrations

[10] Primary constituents shown on the figures include those detected in excess of the PRGs and the natural background concentrations with the greatest frequency or magnitude.
[11] Concentrations of total cPAHs are provided in benzo(a)pyrene toxic equivalent concentrations.

of PAHs detected in deeper soil were greater than those in shallow soil at well MW-8, located hydraulically downgradient of the former gas works operational area.

The concentrations of total cPAHs exceeding the initial PRG have been detected in soil samples collected between depths of 3 and 40 feet. The highest concentrations of total cPAHs were detected in shallow soil, between the depths of 5 and 12 feet, at well MW-3, well MW-6, and boring SP03 and in deeper soil at a depth of 25 feet at well MW-8.

The presence of cPAHs and naphthalenes is a potential indicator of MGP-related releases.[12]

3.7.1.3 Metals

The detectable concentrations or analytical reporting limits for a number of metals exceeded the initial PRGs. However, the concentrations of many of these metals did not exceed the natural background concentrations[13] (Ecology 1994):

- For manganese and antimony, all of the detected concentrations, and most of the reporting limits, are below the background concentrations.[14]
- Cobalt and vanadium were detected in all of the soil samples analyzed for metals, with many concentrations exceeding the initial PRGs; however, the detected concentrations are generally within the range of regional background concentrations.
- Thallium was detected at concentrations above the initial PRGs in most of the soil samples analyzed; a natural background concentration for thallium was not available.

Detected concentrations of cadmium, lead, and zinc are within the range of regional background concentrations at most sample locations, except for borings MW-5, MW-8, and SP03, which are located at the northeast corner of the Former Gas Works Property in the shoreline and Former Ravine fill areas.

Arsenic, chromium, copper, and nickel were detected at concentrations above the initial PRGs and background concentrations at several locations. Figures 3-9 through 3-14 depict the concentrations of arsenic, copper, and nickel[15] in surface and subsurface soil. Concentrations of these metals in subsurface soil do not exceed the initial PRGs, with the exception of arsenic, which was detected at a concentration above the initial PRG but below the natural background concentration. Concentrations of arsenic, copper, and nickel in surface soil exceed the initial PRGs and the natural background concentrations at several locations. Arsenic was detected at concentrations above the natural background concentration at two locations: SP03 (Former Ravine fill area) and MW-3 (within the

[12] Carcinogenic PAHs and naphthalenes can also originate from other sources, including petroleum hydrocarbons or creosote. Forensic analyses, such as PAH fingerprinting, may be useful during the RI to help distinguish and identify potential sources of contamination.
[13] Puget Sound background concentrations of metals were used for screening when available. When not available, Washington State background concentrations were used.
[14] The Puget Sound regional background concentration for antimony has not been researched. The referenced background concentration is based on regional data from the Spokane Basin.
[15] Arsenic, copper, and nickel were mapped in soil because these constituents were also most frequently detected in groundwater at concentrations greater than the surface water or groundwater initial PRGs.

footprint of former gas works operations and the current industrial park). Copper, chromium, and nickel were sporadically detected across the Former Gas Works Property at concentrations above the natural background concentrations, but their maximum concentrations were only slightly above their respective background concentrations (62.7 milligrams per kilogram [mg/kg] versus 38 mg/kg for copper; 60.8 mg/kg versus 48 mg/kg for chromium; and 60.9 mg/kg versus 48 mg/kg for nickel). The sources of these exceedances are unclear from the existing data. Possible sources include contaminated fill, historical industrial operations, or natural background variability.

3.7.2 Groundwater Data

Groundwater samples were collected as part of the investigations conducted in 2007 and 2008. Groundwater samples were collected and analyzed for petroleum hydrocarbons, metals, SVOCs including PAHs, VOCs, and PCBs. Table 3-11 summarizes the number of samples collected for analysis of each constituent and the results of a comparison of detected concentrations to the initial PRGs, which include concentrations protective of groundwater and surface water. The groundwater analytical data are provided in Appendix F.

The constituents detected in groundwater at concentrations greater than the initial PRGs include the following:

- Metals: arsenic, beryllium, chromium (both total and hexavalent), cobalt, copper, lead, manganese, nickel, thallium, vanadium, and zinc;
- PAHs: acenaphthene, benzo(g,h,i)perylene, dibenzofuran, phenanthrene, pyrene, naphthalenes, and total cPAHs;
- Pentachlorophenol (PCP); and
- VOCs: benzene, ethylbenzene, xylenes, 1,2,4-trimethylbenzene, 1,2-dichloroethane, carbon tetrachloride, chloroform, isopropylbenzene, n-hexane, and trichloroethene.

Other than the above-listed constituents, no SVOCs or VOCs were detected at concentrations above the initial PRGs; however, the reporting limits for a subset of SVOCs and VOCs exceed the initial PRGs at a number of locations (Table 3-11 and Appendix F). PCBs were not detected in groundwater; however, the reporting limits for PCBs in all samples were above the groundwater initial PRG (Appendix F).

The existing groundwater data are limited, with one sampling event at 10 locations and no groundwater data collected since 2008. The data are useful for the preliminary identification of COPCs, and they indicate where groundwater impacts may be located. Some of the existing data were collected from wells that are still in place. These wells can likely be used for future monitoring, and the comprehensive data set will likely be useful in evaluating long-term trends in groundwater quality.

VOCs, PAHs, PCP, and metals detected at concentrations above the initial PRGs are discussed in the following subsections by analyte group. The concentration detected at each monitoring well and a comparison to the groundwater initial PRGs are provided for the primary constituents detected at concentrations above the initial PRGs[16] on Figures 3-15 through 3-19.

3.7.2.1 Volatile Organic Compounds

One or more of the BTEX compounds were detected in groundwater samples collected at all of the monitoring wells, except for wells MW-1 and SP02. The detected concentrations of benzene in groundwater are shown on Figure 3-15. The highest concentrations were detected in wells MW-3, MW-6, and MW-8 (in and downgradient of the former gas works operation area).

3.7.2.2 Polycyclic Aromatic Hydrocarbons

Detected concentrations of total cPAHs were above the initial PRGs in groundwater samples collected from wells MW-3 through MW-8 (Figure 3-16) located on the Former Gas Works Property. The highest concentration of total cPAHs in groundwater was detected at well MW-4. There were no detected concentrations of cPAHs in the groundwater samples collected from wells MP04, SP02, MW-1, and MW-2.

The results for other PAHs are the following:

- Dibenzofuran and pyrene were detected at concentrations above the initial PRGs in the groundwater sample collected from well MW-4; and
- Naphthalenes, including 1-methylnaphthalene and naphthalene, were detected in groundwater samples collected from wells SP02, MP04, MW-3, MW-4, MW-5, MW-6, MW-7, and MW-8 at concentrations exceeding the initial PRGs. The highest concentrations of naphthalene were detected at wells MW-4 and MW-8 (Figure 3-17).

3.7.2.3 Pentachlorophenol

PCP was detected in groundwater at a concentration exceeding the groundwater and surface water initial PRGs at well MW-8.

3.7.2.4 Metals

The highest concentrations of metals in groundwater were generally detected at wells MW-3 and MW-4. MW-3 is located in the central portion of the Former Gas Works Property, in the vicinity of the former finished gas storage tanks and former metal finishing operations. MW-4 is located within the Former Ravine fill area, in the central portion of the Sesko Property. Results for specific metals are the following:

- Arsenic was detected in all of the groundwater samples analyzed, at concentrations ranging from 0.6 to 26 micrograms per liter (µg/L), all of which exceed both the groundwater initial PRG and the surface water initial PRG. Figure 3-18 depicts the concentrations of arsenic in groundwater, which are highest in the central portion of the Former Gas Works Property, at wells MW-3 and MW-4

[16] Primary constituents shown on the figures include those detected with the greatest frequency or magnitude above the groundwater initial PRG.

- Hexavalent chromium was detected in groundwater samples collected from wells MW-1 and MW-3 through MW-8 at concentrations exceeding the groundwater initial PRG. The concentrations detected in wells MW-5 and MW-8 also exceed the surface water initial PRG. Figure 3-19 depicts the concentrations of hexavalent chromium in groundwater.
- Total chromium and lead were detected in groundwater at concentrations above both the groundwater initial PRGs and the surface water initial PRGs in the samples collected from wells MW-3 and MW-4.
- Copper and nickel were detected at concentrations exceeding the surface water initial PRGs at most of the sampling locations; none of the concentrations of copper and nickel exceeds the groundwater initial PRGs. The highest concentrations of copper and nickel were detected in groundwater samples collected from wells MW-3 and MW-4.
- Concentrations of cobalt, manganese, thallium, and vanadium exceeding the groundwater initial PRGs were detected in the groundwater sample collected from well MP04.

3.7.3 Sediment Data

Available sediment data for the Site include those collected in 2008 as part of the TBA, in 2010 as part of the 2010 TCRA, and in 2013 as part of the 2013 TCRA. These data sets include the following:

- **2008.** Five surface sediment samples from the beach north of the Former Gas Works Property were analyzed for TPH, VOCs, SVOCs, and metals.
- **2010.** Thirty-two surface sediment samples collected during the 2010 TCRA were analyzed for VOC and SVOCs.
- **2013.** Thirty-nine surface sediment samples collected during the intertidal sediment sampling program were analyzed for total solids (TS), total organic carbon (TOC), and SVOCs.
- **2013.** Seventeen subsurface sediment samples were collected by direct-push methodology at seven locations. Samples from 4 discrete intervals were analyzed for VOCs, and samples from 17 subsurface intervals were analyzed for TS, TOC, and SVOCs.

Table 3-12 presents these sediment data and concentrations relative to the initial PRGs identified in Section 3.1.2. Where applicable, reference values are also presented for natural background concentrations of contaminants in Puget Sound sediments or soils.

Figures 3-20 through 3-24 present the measured concentrations of PAHs in beach sediments at the Site. Data are presented on a dry-weight basis for benzo(a)pyrene, total low-molecular-weight PAHs (LPAHs), total high-molecular-weight PAHs (HPAHs), total cPAHs, and total cPAH toxic equivalent (TEQ) concentrations. The highest PAH concentrations were detected within and near the two removal action areas. East and west of these two areas, concentrations decrease rapidly.

3.8 Existing Data from Other Cleanup Sites

Soil and groundwater data collected on the Former SC Fuels Property include TPH, BTEX, and lead (Section 3.4). The majority of the soil data were collected prior to and during remedial actions (removal of USTs and surrounding contaminated soil), which occurred in 2002. The most recent groundwater monitoring data are from January 2007. During that sampling event, concentrations of benzene were detected in groundwater at concentrations up to 88 μg/L on the Former SC Fuels Property and up to 49 μg/L in the eastern portion of the Pennsylvania Avenue right-of-way (GeoScience Management 2007). The extent of benzene detected in groundwater (detection limit 1 μg/L) in 2007 is shown on Figure 3-25.

3.9 Data for Port Washington Narrows and Dyes Inlet

A number of high-quality sediment and tissue studies were identified for the Port Washington Narrows and Dyes Inlet. The locations from which sediment and tissue data with measured PAH concentrations were collected are shown on Figure 3-26. These data sets are not used for data screening or COPC evaluation (see Section 4.4) but provide valuable information about conditions in the vicinity of the Site.

3.9.1 Sediment Quality Data

Figures 3-27 and 3-28 present measured concentrations of benzo(a)pyrene and total cPAHs in sediments, respectively. Data are presented on a dry-weight basis. Ecology's current Draft Sediment Cleanup Users Manual II (Ecology 2013) recommends the use of the 90th percentile from data sets to evaluate natural and regional background concentrations. The 90th percentile concentrations of benzo(a)pyrene and total cPAHs in surface sediment samples collected during the *Bold* Summer 2008 Survey (USACE et al. 2009) are approximately 10 micrograms per kilogram [μg/kg] and 50 μg/kg, respectively. Relative to the 90th percentile of the 2008 data, the concentrations of benzo(a)pyrene and total cPAHs in sediments from within the Port Washington Narrows, Dyes Inlet, and Sinclair Inlet are elevated. The vast majority of the detected values exceed the 90th percentile values from the 2008 data set.

The measured dry-weight concentrations of LPAHs and HPAHs in sediment are presented in Figures 3-29 and 3-30, respectively. The 90th percentile concentrations of LPAHs and HPAHs in surface sediment samples collected during the *Bold* Summer 2008 Survey are 10.9 and 75.1 μg/kg, respectively. Relative to the 90th percentile of the 2008 data, the LPAH and HPAH concentrations detected in Port Washington Narrows, Dyes Inlet, and Sinclair Inlet show the same magnitude of elevated concentrations as that shown in the cPAH data.

3.9.2 Tissue Quality Data

Figures 3-31 and 3-32 provide a synopsis of available existing PAH testing data for various aquatic organisms. Tested organisms included mussels, clams, and crabs. The data for total cPAHs are presented on both a wet-weight basis (Figure 3-31) and a lipid-normalized basis (Figure 3-32).

3.9.3 Surface Water Quality Data

No current water quality data for chemical contaminants within the Port Washington Narrows has been identified. Several studies have been conducted to assess potential contaminant inputs to Dyes Inlet and adjacent waters (Crecelius et al., 2003). The results of these and other available studies will be used qualitatively for the evaluation of potential nonpoint sources of pollution but will not be relied upon for the baseline risk assessment.

4 Preliminary Conceptual Site Model

This section presents the preliminary CSM, which has been developed based on available historical information, the current understanding of the environmental setting, and the findings of previous investigations, as presented in Sections 2 and 3. The CSM is a description of environmental conditions that includes sources of contamination, contaminant fate and transport in Site media, and potential routes of contaminant exposure for human and environmental receptors. A three-dimensional graphical CSM illustrating representative potential historical sources and migration of contaminants at the Site is provided on Figure 4-1, and a conceptual CSM cross section is shown on Figure 4-2. The CSM will be developed further during the RI and risk assessment as more Site-related information and data are gathered.

4.1 Potential Sources of Contamination

This section summarizes potential sources of contamination on the Former Gas Works Property and on surrounding properties. The potential sources and locations associated with known and documented operations (both MGP and other) are presented in the following sections; however, this discussion does not include undocumented or currently unknown potential sources or source areas, which may be identified through the collection and evaluation of data during the RI.

4.1.1 Former Gas Works Property Sources

Potential sources of contamination on the Former Gas Works Property include historical activities associated with the former gas works, as well as other activities on the property that are unrelated to gas works operations.

4.1.1.1 Sources Related to Gas Works Operations

The potential primary sources associated with the production of manufactured gas are depicted on Figure 2-3. The area in which the gas production process occurred is divided into potential source areas based on the predominant use and subsequent primary potential release mechanisms associated with each area. The primary potential source areas include the following:

- **Coal/Coke Briquettes Area.** As described in Section 2, solid feedstocks (coal and coke briquettes) were transported to the Former Gas Works Property by barge and offloaded and transported over the water, beach, and bluff to a concrete surface storage area in the northwest corner of the Former Gas Works Property. Coke briquettes have been observed on the beach and bluff, suggesting spills during the transport process. Additionally, coal/coke dust may have been swept off the concrete storage slab onto the surrounding ground surface.
- **Tar and Petroleum Transfer Area.** Petroleum products were delivered to the Former Gas Works Property and tar was removed from the Former Gas Works Property by barge. Petroleum and tar from pipelines along the dock and at the connection to the barges may have been released directly to sediment or surface

water. A pipeline presumably ran between the dock and the byproduct storage area to transport tar to the dock, but the location is unknown.

- **Petroleum Storage Area.** Petroleum products were stored in ASTs in the northeastern portion of the Former Gas Works Property. The products reported to have been stored in these tanks include gasoline and diesel fuel oil. Transfer piping presumably ran from the storage tanks to the furnaces, but the exact location of transfer piping is unknown. Petroleum may have been released from tanks and piping to soil at the surface or shallow subsurface in this area.
- **Gas Generation and Purification Area.** The main process area was located in the central portion of the Former Gas Works Property and included the furnaces, scrubber, gas holder, and purifier. The primary potential sources associated with the gas works process consist of spills, drips, and leaks of spent liquids, oils, gas liquor, tar, and tar-water mixtures from aboveground equipment, piping, and storage tanks to the ground surface.
- **Residuals Management Area.** A map of the former plant shows tar wells and a residue cistern to the east of the purifiers. These were likely used for separation of tar-water emulsions prior to resale of the tar. The details of the tar wells and residue cistern are unknown, but they likely extended into the shallow subsurface and may have either been lined or unlined at the base. A second area south of the main plant building was reportedly used for storage and/or separation of tar and tar-water emulsions in a tar pit. Oils and tar may have been released to the surface around these features or the subsurface beneath them.
- **Tar and Light Oil Storage Area.** The southern portion of the Former Gas Works Property was used for the storage of tar and light oil in ASTs. Tar and light oil may have leaked or been spilled onto the ground surface in the vicinity of the ASTs. Finished gas may have contained small amounts of oil that condensed in the distribution piping and were collected in the drip tank. Light oil may have been released to the shallow subsurface soil in the vicinity of the pipes and tank.
- **Former Drainage Line Area.** During the 2010 TCRA, a former drainage line on the Sesko Property that discharged to the Port Washington Narrows was identified. Tar-like hydrocarbons were identified in this drainage line, which was plugged during the 2010 TCRA (see Section 3.3.1). The drainage line is consistent with a former City CSO outfall documented in historical files. Wastewater and associated contaminants may have been discharged from this drainage line during operation of the former gas works.
- **Ravine Fill Area and Shoreline Fill Area.** Historical documents reference the surface disposal of gas works byproducts into the western portion of the Former Ravine, to the east of the gas generation and purification area, and along the bluff to the north of the gas generation and purification area. Materials that were reportedly placed along the shoreline include ash, cinders, slag, and soot. Materials that were reportedly placed in the Former Ravine include ash, cinders, slag, soot, spent scrubber media (tar-laden wood chips and shavings), and spent purifier filter media (wood chips and/or iron oxide). The approximate areas of potentially gas-works-related fill are shown on Figure 2-3.

4.1.1.2 Sources Related to Other Operations on Former Gas Work Property

Other potential primary sources are associated with activities conducted after the shutdown and demolition of the former gas works, or they were conducted in the immediate vicinity of the former gas works. These sources are shown on Figure 2-4 and summarized as follows:

- **Bulk Petroleum Storage.** Petroleum products were delivered to Lent's at a dock offshore of the Sesko Property and stored in ASTs for distribution by fuel delivery vehicles. Petroleum may have been released from piping and storage tanks to the ground surface and/or the shallow subsurface.
- **Varied Light Industrial Use.** Since the shutdown of the former gas works, the McConkey Property has been used for miscellaneous light industrial activities, including vehicle parking, metals fabrication, and equipment storage. Ecology Site inspections in 1992, 1993, and 1994 indicated poor housekeeping practices associated with some of these operations. These operations are potential sources of solvents, metals, and petroleum hydrocarbons, which may have been released to the ground surface as either solids (sandblast grit, paint sludges, etc.) or components of liquids.
- **Equipment Storage and Repair and Debris Filling.** In addition to the bulk petroleum storage described above, activities on the Sesko Property since the shutdown of the former gas works included boat maintenance and storage, automobile salvage, and equipment and debris storage. These activities may be sources of contaminants to soil, sediment, and surface water by direct discharge, dumping, or spills to the ground surface.
- **Other Operations.** Other operations have reportedly included filling of the Former Ravine and shoreline areas, particularly on the Sesko Property. These operations may have included disposal of incinerator refuse, garbage, and ashes; placement of concrete and piping debris; and/or placement of miscellaneous metal, concrete, and fiberglass debris associated with maintenance and salvage of boats and equipment. Fill placed along the shoreline and in the Former Ravine may have included materials that contained hazardous substances. Although the presence of fill material alone does not necessarily represent a contaminant source, hazardous substances associated with the fill may subsequently migrate to surrounding subsurface soil or groundwater.

4.1.1.3 Stormwater Discharge

Stormwater discharging to the Port Washington Narrows may contain contaminants and is a potential source of contamination to sediments or surface water. The outfalls that historically have captured or currently capture water at the Former Gas Works Property are the following:

- **Historical City Stormwater/CSO Outfall.** As noted in Section 4.1.1.1 (list item "Former Drainage Line Area"), a historical drainage line and outfall were located within and offshore of the Sesko Property. A section of the drainage line on the beach was reportedly removed by the City during installation of a force main in the 1990s. The drainage line was plugged and partially removed as part of the

2010 TCRA (see Section 3.3.1). An upland manhole and storm drainage lines believed to be connected historically to the drainage line were plugged as part of the 2013 TCRA.

- **McConkey Drainage Line.** A small drainage line discharges stormwater from a shallow catch basin on the McConkey Property to the Port Washington Narrows.

4.1.2 Sources Related to Operations on Adjacent Properties

Potential primary sources on adjacent properties include the following:

- **Bulk Petroleum Storage.** Petroleum products were delivered by barge to bulk fuel storage facilities at the Former ARCO Dock, the Former Sesko Dock, and the former SC Fuels Dock and stored in ASTs or USTs for distribution by fuel delivery vehicles. These petroleum storage facilities were located on the Former ARCO Property located west of the former gas works and the Former SC Fuels Property. Petroleum may have been released from piping and storage tanks to the ground surface and/or the shallow subsurface while these operations were ongoing.

- **Varied Light Industrial Use.** The Penn Plaza Property has been used for miscellaneous light industrial activities, including spray painting, a pipe shop, vehicle parking for a petroleum distributor, truck repair electroplating, metals fabrication, and equipment storage. Ecology Site inspections in 1992, 1993, and 1994 indicated poor housekeeping practices associated with some of these activities. These activities are potential sources of solvents, metals, and petroleum hydrocarbons, which may have been released to the ground surface as either solids (sandblast grit, paint sludges, etc.) or components of liquids.

4.1.2.1 Stormwater Discharge

A number of documented stormwater and CSO outfalls are located within the Port Washington Narrows and Dyes Inlet (Section 2.7), including the two outfalls described in Section 4.1.1.3. Other nearby outfalls or discharge lines include the following:

- **Current City Stormwater/CSO Outfall**. An active City stormwater/CSO outfall is located along the Port Washington Narrows, offshore of the end of Pennsylvania Avenue. This outfall is located adjacent to the 2010 TCRA area (Figure 3-2).

- **Drain Line.** A drain line from an oil-water separator on the Former SC Fuels Property discharges to the Port Washington Narrows.

4.2 Contaminant Migration and Transformation

Contaminants derived from the sources described in Section 4.1 may have been released to soil (surface and shallow subsurface), sediment, and/or surface water. Representative potential releases (e.g., leaks or spills from equipment, tanks, or piping; placement of contaminated fill materials; and discharges from outfalls) are shown conceptually on Figures 4-1 and 4-2. The released contaminants may have migrated from one location to another or from one medium to another. Contaminants may also undergo attenuation or transformation processes within media. The contaminant migration pathways and transformation processes are described in the following subsections.

4.2.1 Migration Pathways

Examples of potential contaminant migration pathways between media are shown conceptually on Figures 4-3, 4-4, and 4-5 and include the following:

- Migration of contaminants from surface soil to subsurface soil (e.g., leaching or product migration);
- Contaminant leaching or NAPL migration from soil/NAPL to groundwater;
- Groundwater/NAPL transport within the saturated zone;
- Groundwater discharges to surface water;
- Contaminant partitioning between groundwater and sediments (including sediment porewater);
- Migration of volatile NAPL/soil/groundwater contaminants to air;
- Migration of surface soil contaminants as fugitive dust;
- Release of surface soil contaminants to stormwater;
- Uptake of contaminants by terrestrial or aquatic biota; and
- Migration of contaminated sediments by sediment transport.

Based on the data collected to date (see Section 3.7), contaminants have been identified in soil, groundwater, and sediment. No Site-specific surface water, air, or tissue data are available. Contaminant occurrences in these media may be due to direct releases or subsequent migration, for instance:

- Soil contamination may be the result of contaminated fill materials, downward flows of NAPL releases[17] through the subsurface and the coating of soil grains, or sorption of contaminants from other media (e.g., soil vapor, infiltrating stormwater, or groundwater).
- Groundwater contamination may be the result of direct discharge of contaminated aqueous materials and their migration downward through the subsurface and mixing with groundwater, leaching of NAPL in contact with groundwater, or stormwater infiltration of the subsurface, leaching of contaminants from NAPL or contaminated soil, and contaminant mixing with groundwater.
- Contaminants in sediment may be the result of direct releases to surface sediments (e.g., documented discharges from outfalls, undocumented spills, or leaks from dock piping and transfer operations); subsurface migration of contaminated groundwater or NAPL from the uplands, and migration through sediments; or a combination of sources. In particular, two sediment "hot-spot" areas were addressed by the 2010 and 2013 TCRAs:

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[17] Liquid releases generally move downward, through the subsurface by means of gravity, but they may move laterally by preferential migration pathways if a barrier (e.g., low-permeability soils or, for NAPLs that are less dense than water, groundwater) is encountered.

- The 2010 TCRA addressed a drain pipe that contained residual NAPL and surrounding contaminated sediments, which appeared to be the primary source of contamination in this area. The historical and ongoing contribution to sediment contamination from other potential sources in this area, including groundwater discharge, stormwater runoff, and the City CSO, is unknown.
- The 2013 TCRA addressed an area of heavy sheen located in shallow subsurface sediments and solid surficial material containing high PAH concentrations. It is likely that the solid surficial material, which would be immobile in the subsurface, was placed at or near its locations; however, the source of the material is unknown. The source of the subsurface sheen is also unknown. During the TCRA investigation, a sheen was observed up to the base of the bluff. However, there are insufficient data to determine whether this contamination is contiguous with contamination in the upland.

Representative migration pathways, including subsurface migration pathways, are indicated on Figures 4-1 and 4-2.

4.2.2 Transformation Processes

In addition to contaminant migration pathways, contaminant concentrations in media can be reduced or attenuated by various combinations of natural processes. Examples of such processes include the following:

- Chemical or biological degradation of contaminants in soils, groundwater, sediments;
- Tidally induced mixing of groundwater near the groundwater/surface water interface;
- Natural recovery of marine sediments by burial, mixing, and/or degradation processes; and
- Metabolic transformation or elimination of chemical contaminants from the tissues of upland or aquatic biota.

4.3 Exposure Pathways and Receptors

Exposure pathways and receptors that may be most relevant to the RI and risk assessment are summarized on Figures 4-3, 4-4, and 4-5.These figures illustrate how certain human and ecological receptors may use the Site and the impacted media that they could reasonably contact.

Figure 4-3 illustrates different exposure pathways that could affect people using the Site or nearby areas. The potential exposure of people to Site-related COCs differs in terms of both how those people use the Site and which areas of the Site are used. (i.e., beach/aquatic areas and upland areas). Some land uses could also change over time. For example, the Site is not zoned for residential land use, but as part of the risk assessment activities, it may be prudent to evaluate potential future residential land use to understand the implications of changes in land use or zoning. Similarly, shellfish harvesting in the

Port Washington Narrows is restricted due to shellfish harvesting closures unassociated with the former gas works. However, it may be prudent to evaluate potential future shellfish harvesting to understand potential exposures should those shellfish harvesting restrictions be lifted.

Preliminary complete current and future human exposure pathways to contaminated media include dermal contact with and incidental ingestion of soil or sediment, dermal contact with groundwater, inhalation of fugitive dust and vapors, and consumption of fish/shellfish that are potentially contaminated with bioavailable Site-related contaminants. Preliminary incomplete current and future human exposure pathways will be evaluated further as part of the RI and risk assessment (see Section 6 for planned RI and risk assessment methodology). The preliminary human exposure scenarios relevant to the Site include the following:

- Human Use of Beach/Aquatic Site Areas:
    - Recreational Beach Users. There is a potential for limited recreational beach use by individuals residing near the Site. During recreational use of the beach, these individuals could be exposed to Site-related COCs in sediment and surface water.
    - Consumers of Fish/Crab from the Port Washington Narrows. The portions of the Port Washington Narrows adjacent to the Former Gas Works Property currently support the collection and consumption of fish and crabs under WDFW regulations. The Port Washington Narrows is also a Usual and Accustomed area of the Tribe. Consumers of fish and crabs may be exposed to Site-related COCs through incidental ingestion of sediment and surface water during harvesting activities.
    - Consumers of Shellfish at the Site (Currently Restricted by Shellfish Harvesting Closures). The portions of the Port Washington Narrows adjacent to the Former Gas Works Property are currently closed to shellfish harvesting (due to water quality concerns associated with CSOs and other non-Site-related concerns) by Washington State Department of Health; however, exposures associated with shellfish harvesting will be evaluated to understand potential risks should the shellfish harvest restrictions be lifted. Consumers of shellfish may be exposed to Site-related COCs through incidental ingestion of sediment and surface water during harvesting activities.
    - Beach Construction/Excavation Workers. This scenario relates to workers performing utility upgrades or maintenance or other activities that involve the disturbance of sediment in the beach area adjacent to the Former Gas Works Property. Beach construction workers could be exposed to Site-related COCs in surface and subsurface beach sediment.
- Human Use of Upland Site Areas:
    - Occupational Workers. The Former Gas Works Property and the properties in the vicinity are zoned for industrial uses. Occupational workers at the Site could be exposed to Site-related COCs in surface soil and vapor.

- Upland Construction/Excavation Workers. This scenario relates to workers performing utility upgrades or maintenance or other activities that involve the disturbance of soil at the Former Gas Works Property and the properties in the vicinity. Upland construction workers could be exposed to Site-related COCs in surface and subsurface soils and vapor.
- Potential Future Residential Users of the Site (Not a Current or Planned Use). The Former Gas Works Property and the properties in the vicinity are zoned for industrial uses, and this is expected to remain the case for the foreseeable future. However, the potential for exposures of future residents may be appropriate to evaluate as part of the risk assessment to understand potential implications should properties within the Site be converted to residential uses. On-site residents could be exposed to Site-related COCs in surface soils and vapor. No water supply wells are located on or near the Former Gas Works Property, but consumption of groundwater has been retained as a potential pathway for screening, pending further evaluation of groundwater beneficial uses.

The Site and vicinity are used by a variety of upland and aquatic species. An initial list of species common to the region has been compiled (Table 4-1), using locally available published sources. Listed in the table are species that use or may occasionally use the Site and vicinity. Species that are classified as threatened or endangered are identified in the table. The species listed in Table 4-1 are grouped into representative categories to illustrate different ecological exposure pathways. Exposure pathways relevant to these representative species are presented in Figure 4-4 for aquatic (i.e., fish) and aquatic-dependent (e.g., heron and river otter) receptors and in Figure 4-5 for terrestrial receptors.

Figure 4-4 provides examples of aquatic wildlife receptors with potentially complete exposure pathways: direct contact with and ingestion of sediment, porewater, and marine water; and consumption of benthic invertebrates, fish, and other potentially contaminated prey. The representative aquatic receptors listed in Figure 4-4 include the following:

- **Piscivorous Mammals (e.g., Harbor Seals).** There is a potential for limited exposure of piscivorous mammals foraging at the Site. Potentially complete exposures are associated primarily with consumption of aquatic biota and, to a lesser extent, with exposure to sediment and surface water.
- **Piscivorous Raptors (e.g., Ospreys).** There is a potential for limited exposure of piscivorous raptors foraging at the Site. Potentially complete exposures are associated primarily with consumption of aquatic biota and, to a lesser extent, with exposure to surface water.
- **Shore Birds (e.g., Herons and Sandpipers).** There is a potential for exposure of shore birds residing or foraging at the Site. Potentially complete exposures are associated primarily with consumption of aquatic biota, incidental ingestion of sediment, and, to a lesser extent, with exposure to surface water.
- **Piscivorous Fishes (e.g., Rockfish).** Piscivorous fishes residing or foraging at the Site may potentially be exposed to Site-related COCs in sediments and surface water.

- **Omnivorous Fishes (e.g., Sculpins).** Omnivorous fishes residing or foraging at the Site may potentially be exposed to Site-related COCs in sediments and surface water.
- **Benthivorous Fishes/Shellfish (e.g., Flatfish, Bivalves, and Crabs).** Benthivorous fish/shellfish residing or foraging at the Site may potentially be exposed to Site-related COCs in sediments and surface water.
- **Benthic Invertebrates (e.g., Benthic Infauna Community).** Benthic invertebrates residing at the Site may potentially be exposed to Site-related COCs in sediments and porewater.
- **Macrophytes (e.g., Algae and Kelp).** Macrophytes residing at the Site may potentially be exposed to Site-related COCS in sediment and surface water.

The upland properties at the Site have historically been developed and used for industrial operations. However, portions of these properties include habitat that could be used by terrestrial ecological receptors. These areas primarily include the vegetated areas of the Former Ravine and the bank. Terrestrial ecological receptors with potentially complete exposure pathways are illustrated on Figure 4-5 and include the following:

- **Avian Predators (e.g., Robins).** There is a potential for exposure of avian predators foraging or nesting at the Site. Primary exposure pathways for these receptors include the consumption of soil invertebrates and incidental ingestion of Site soil.
- **Carnivores (e.g., Coyotes).** There is a potential for limited exposure of carnivores foraging at the Site. Primary exposure pathways for these receptors include the consumption of soil invertebrates and small mammals and incidental ingestion of Site soil.
- **Omnivores (e.g., Raccoons).** There is a potential for limited exposure of omnivores foraging at the Site. Primary exposure pathways for these receptors include the consumption of plants and soil invertebrates and incidental ingestion of Site soil.
- **Herbivores (e.g., Voles).** There is a potential for exposure of herbivores residing at the Site. Primary exposure pathways for these receptors include the consumption of plants and incidental ingestion of Site soil.
- **Insectivores (e.g., Shrews).** There is a potential for exposure of insectivores residing on the Site. Primary exposure pathways for these receptors include the consumption of soil invertebrates and incidental ingestion of Site soil.
- **Upland Vegetation.** There is a potential that plants growing at the Site could be exposed to Site-related COCs in soil.
- **Soil Invertebrates.** There is a potential for exposure of earthworms and other biota living at the Site. Primary exposure pathways for these receptors include direct contact and incidental ingestion of Site-related COCs in soil and consumption of terrestrial biota.

4.4 Contaminants of Potential Concern

This section identifies preliminary COPCs based on: (1) contaminants typically associated with the former gas works process (carbureted water gas); (2) contaminants associated with other potential historical sources within the initial study area (ISA; see Section 6.1); (3) contaminants detected during previous Site investigations; and (4) other EPA contaminants of interest. The COPCs, and ultimately the COCs, that are determined to apply to the Site-related decisions may include some, none, or all of the contaminants identified in this section. The COCs that are ultimately determined to apply to the Site-related decisions will be established on the basis of data and information that are collected as part of the RI/FS process.

Contaminants typically associated with carbureted water-gas manufacturing processes include the following:

- Light aromatic hydrocarbons, such as BTEX compounds;
- Heavier aromatic hydrocarbons, including PAHs;
- Other SVOCs, such as tar acids (e.g., phenol and cresols) and heterocyclic aromatics (e.g., carbazole and dibenzofuran); and
- Cyanide and sulfides associated with spent purifier materials.

Other historical processes with the potential for releases at the Site include petroleum transfer and storage, metal fabrication, and vehicle and equipment salvage and repair. Contaminants typically associated with these processes include solvents (VOCs), petroleum hydrocarbons (including BTEX and PAHs), and metals.

EPA has identified polychlorinated biphenyls (PCBs) and pesticides as other contaminants of interest at the Site. PCBs are man-made organic chemicals, manufactured between 1929 and 1979, and used in industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; in paints, plastics and rubber products; and in pigments and dyes. PCBs may still be present in products and materials that were manufactured before 1979, including electrical transformers and capacitors, fluorescent light ballasts, adhesives, oil-based paint and caulking. Pesticides are substances, or mixtures of substances, intended for preventing, destroying, repelling, or mitigating any living organisms (e.g. insects, mice, weeds, fungi, microorganisms) that occur where they are not wanted or that cause damage to crops, humans or other animals. The term pesticides applies to insecticides, herbicides, fungicides, and various other substances used to control pests.

The preliminary COPCs for the Site fall within the following groups of contaminants:

- VOCs, as identified and quantified by EPA Method 8260C.
- SVOCs, including carcinogenic- and non-carcinogenic PAHs, as identified and quantified by EPA Method 8270D/SIM.
- Metals, as identified and quantified by EPA Methods 200.8/6010/6020/7471B.
- PCBs, as identified and quantified by EPA Method 8082.
- Pesticides, as identified and quantified by EPA Method 8081B.

- Cyanide, as identified and quantified by EPA Method 9014.

Table 4-3 identifies the specific contaminants within each group that are considered preliminary Site COPCs. Non-toxic metals including calcium, chloride, iodine, magnesium, phosphorous, potassium and sodium, are essential nutrients and are not identified as COPCs even though some of them have been previously detected at the Site. The preliminary COPCs were selected if information indicates they are confirmed or suspected to be present at the Site.

Table 4-3 is not intended to provide an exhaustive and complete list of all COPCs for the Site. The scope of work for the RI will include analysis and reporting of the full standard list of contaminants for each analytical method, as described in detail in the Upland SQAPP and Marine SQAPP (Appendices A and B, respectively). Initial Site investigations, which will investigate and characterize potential sources of contamination at the Site (see Section 6.5), will include analysis of representative samples for all preliminary COPCs. The data collected during this first phase of work will be screened against initial PRGs and natural background concentrations (if available) to determine which analytes should be carried forward as COPCs for subsequent phases of sampling

5 Potential Remedial Approaches

This section identifies potentially applicable remedial technologies, potential remedial approaches, and the data required to evaluate the feasibility of each technology to meet the RAOs. The remedial approach is typically a combination of remedial technologies

5.1 Remedial Technologies

Site remediation to achieve RAOs typically occurs by implementation of a combination of remedial technologies. Depending on the Site-specific circumstances, the use of remedial technologies may result in the complete elimination or destruction of hazardous substances at the Site, the reduction of hazardous substances at the Site, the reduction or elimination of migrating hazardous substances at the Site, or some combination of these effects. These technologies may be used in combination with engineering controls (e.g., barriers such as fences or caps) or institutional controls (i.e., non-engineered controls such as land use restrictions) when hazardous wastes remain at the Site. Remedial technologies are often categorized by the following general response actions:

- **Monitored Natural Attenuation.** Natural attenuation is the reduction of contaminant concentrations at the point of exposure over time by means of natural processes, such as sedimentation, sorption, dispersion, and/or biodegradation. Monitoring documents that the processes are occurring at the desired rates. For sediment, this general response action is referred to as monitored natural recovery.
- ***In Situ* Containment.** *In situ* containment involves confining hazardous substances in place by the placement of physical barriers or hydraulic controls. Containment technologies can be designed to prevent contact with and/or migration of hazardous substances.
- ***In Situ* Treatment.** *In situ* treatment technologies can potentially reduce the concentration, mobility, and/or toxicity of COCs.
- **Removal.** Contaminated materials can be physically removed from a site and treated and/or disposed of at either an on-site or an off-site permitted disposal facility.
- ***Ex Situ* Treatment.** *Ex situ* treatment technologies destroy or immobilize contaminants in media that have been removed from the subsurface.
- **Disposal.** Disposal technologies include the placement of contaminated solid media in on-site or off-site landfills or the discharge of contaminated water to a publicly owned treatment works.

Preliminary lists of potential remedial technologies for NAPL, soil, groundwater, and sediment at the Site are provided in Tables 5-1 through 5-4, respectively.

5.2 Remedial Approaches at Other MGP Sites

Hundreds of MGP sites around the country have been through or are undergoing an RI/FS and cleanup action. Table 4-2 identifies remedial approaches that have been fully or partially implemented at MGP sites with characteristics (e.g., geology and presence of adjacent surface water bodies) that are similar to the Bremerton Gas Works Site. Common actions have included combinations of removal with off-site disposal or on-site treatment, solidification/stabilization, and institutional and engineering controls. Other technologies have included pump-and-treat, bioremediation, *in situ* chemical oxidation, barriers, and NAPL collection.

5.3 Feasibility Study Data Gaps

As part of the FS, the potential remedial technologies identified in Tables 5-1 through 5-4 will be screened on the basis of effectiveness, implementability, and cost and assembled into remedial alternatives. The assembly and detailed analysis of alternatives requires a good understanding of Site characteristics. In general, data gathered during the RI to characterize physical characteristics of the Site, delineate the nature and extent of contamination, evaluate contaminant fate and transport, and assess risks to human health and the environment will also support the development and evaluation of remedial alternatives. Data gaps related to the Site characterization were identified in the Scoping Memorandum (Aspect and Anchor QEA 2015) and are summarized in Section 6.2 of this Work Plan.

Site characterization data will need to be sufficient to develop hydraulic or contaminant fate-and-transport models that may be needed to assist in the engineering evaluations during the FS (e.g., in developing and evaluating alternatives that use groundwater extraction or dewatering). Site characterization will also need to delineate not only the extent of contamination but also the extent of contaminant source areas or "hot spots."

In addition to the Site characterization data described above, valuable Site-specific information for developing and evaluating remedial alternatives also includes the following:

- Geotechnical data (e.g., for developing excavation and shoring plans), including penetration test data, soil moisture content, Atterberg limits, and gradation;
- Recoverability characteristics of NAPLs, if present;
- Waste characteristics (e.g., toxicity characteristic leaching procedure [TCLP]) to determine potential disposal and/or treatment options; and
- Evaluations of current velocity and sediment substrate study by means of a towed video camera, to evaluate physical forces and geologic formations.

Additional technology-specific data needs may be identified as more data are collected and the FS alternatives are developed. These may include Site characterization data, bench testing, or pilot testing of potential remedial technologies. The process for identifying bench or pilot treatability testing required for the FS is discussed in Section 7.6.

6 Work Plan Rationale

This section describes the basis and approach for the RI data collection program. It includes the following information:

- Description and basis for the initial study area (ISA) that is to be characterized during the RI (Section 6.1);
- Summary of data needed to complete the RI and FS (Section 6.2);
- Approach for completing the risk assessment (Section 6.3);
- DQOs for collected data (Section 6.4);
- The approach for filling data gaps (Section 6.5); and
- Potential contingency studies that may be required after initial data collection has been completed (Section 6.6).

Details of the specific sampling and analysis programs for the upland and marine areas are provided in the Upland and Marine SQAPPs (Appendices A and B).

6.1 Initial Study Area

The purpose of defining the ISA is to provide a focused area for sampling and analysis in the initial phase of the RI/FS (AOC, EPA 2013a). The ISA is not intended to define the Site boundaries. The Statement of Work (SOW) for the AOC anticipates "the ISA will encompass the area of operation of a former manufactured gas plant (MGP)…, including the area where contaminants from the area of operation have come to be located, which includes upland, beach and sediments." The ISA has been developed according to the guidelines established by the SOW and includes an upland portion and a sediment portion. The rationale for the upland and sediment portions of the ISA is explained further in the following subsections.

6.1.1 Upland Initial Study Area

The upland portion of the ISA (Figure 6-1) includes the Former Gas Works Property and portions of neighboring properties where gas works operations, including byproduct storage and disposal, are documented or suspected to have occurred. This includes the northern portion of the Penn Plaza Property where a drip tank was located and the eastern portion of the Sesko Property where materials from the former gas works process may have been placed in the Former Ravine. The upland portion of the ISA also includes areas where contamination associated with operations other than the former gas works could potentially be commingled with contamination from the gas works. These non-gas-works operations include the former Lent's bulk petroleum storage tank farm on the Sesko Property, petroleum pipelines located in the northern portion of the Penn Plaza Property and the Sesko Property, and various light industrial operations on the McConkey and Penn Plaza Properties.

Consistent with the SOW, the proposed ISA encompasses all upland areas where contaminants associated with the former gas works are likely to be located. The existing data collected from areas near the boundaries of the ISA suggest that contamination associated with the former gas works may not extend beyond the ISA. More data are needed to determine if this is the case. The existing data include the results of soil and groundwater sampling from well MW-1 on the Penn Plaza Property, borings MP03 and MP02 within Thompson Drive, borings SP01 and SP02 on the Sesko Property, and explorations associated with the Former SC Fuels Property to the east of the ISA.

The first phase of the RI will characterize the nature and extent of contamination within the ISA and assess the subsurface characteristics that may influence the migration of contaminants. These data will be used to determine where additional investigation may be warranted. Investigations outside of the ISA, if needed, would then be specifically designed and implemented to focus on the characterization of identified issues.

6.1.2 Sediment Initial Study Area

The sediment portion of the proposed ISA (Figure 6-2) comprises intertidal and subtidal areas in the general vicinity of the Former Gas Works Property. The sediment portion of the ISA is described as follows:

- Historical potential source areas associated with the former gas works (including the Former Gas Works Dock and the former drainage line) have been included.
- All beach sediments adjacent to the Former Gas Works Property that exhibited elevated PAH concentrations during the 2013 TCRA have been included.
- The offshore boundary of the ISA extends out past midchannel in the Port Washington Narrows, well past the bathymetric low point in the channel. This addresses potential migration pathways associated with groundwater and/or NAPL migration and those associated with potential sediment transport.
- The eastern and western boundaries of the ISA extend between 500 and 1,000 feet in an east-west direction from the Former Gas Works Property, allowing documentation of the potential transport of sediments that may have resulted from the east-west tidal currents within the Port Washington Narrows.

The sediment portion of the ISA includes multiple potential sources that are unassociated with historical activities on the Former Gas Works Property: multiple historical petroleum transfer docks, multiple stormwater and CSO outfalls, and the Port Washington Marina.

As part of the RI/FS activities related to sediments, there is a need to understand regional trends in sediment quality or water quality that may affect either current Site conditions or result in future recontamination of the Site. Therefore, sampling activities for sediments and surface water will not be exclusively confined to the ISA. Some sampling during the RI/FS will occur outside the sediment portion of the ISA. However, the investigation and remediation of non-Site-related contaminant sources that are located outside the ISA is not an objective of this RI/FS.

6.2 Data Needs

The data needs have been identified through the RI/FS scoping process and development of the Final Scoping Memorandum (Aspect and Anchor QEA, 2015). This section discusses the data needs that affect all components of the RI/FS process. The general data needs, specific data gaps, and planned RI data collection methods for the upland and marine portions of the Site are summarized in Tables 6-1 and 6-2, respectively. The general approach for addressing the data needs is summarized in Section 6.6.

6.2.1 Site Physical Characteristics

Characterization of the physical properties of the soil is necessary to evaluate the contaminant migration pathways and the remedial options. Soil samples will be collected from all typical lithologic units, as feasible, for physical characterization to include grain size, density, moisture content, and organic carbon content.

The data needs associated with the hydrogeology of the Site include data to define aquifer and aquitard units across the Site, evaluate the hydraulic conductivity of aquifer units, and understand the influence of tidally influenced surface water on groundwater flow and contaminant transport from the Site. The installation and sampling of groundwater monitoring wells is needed to provide these physical data, as well as samples to define the extent of groundwater contamination. The distribution of groundwater contaminants is associated with groundwater flow, which may be affected by seasonal variations in groundwater levels due to precipitation, as well as interaction with surface water. The information needed to satisfy these data needs will be obtained by sampling groundwater for chemical and geochemical parameters, logging geologic information, measuring static and transient water levels, and performing aquifer testing.

To evaluate physical forces and overall geologic formations in the sediment portion of the ISA and the adjacent portions of the Port Washington Narrows, evaluations of current velocity, and sediment substrate studies by means of a towed video camera are needed. Current velocity will be measured at two depth profiles (near-bottom and midchannel) along each transect and will be used to indicate potential impacts of current velocity on sediment stability within the ISA and the Port Washington Narrows. Similarly, towed-camera surveys will be conducted to document the sediment substrate in perpendicular and parallel transects in the vicinity of the sediment ISA and the adjacent Port Washington Narrows.

6.2.2 Nature and Extent of Contamination

A primary objective of the RI is to delineate the nature and distribution of contamination in the potentially affected media at the Site, which include soil, groundwater, air, surface water, and sediment. Samples of each potentially affected medium will be collected for chemical analysis of the Site COPCs throughout the RI process.

Because NAPL is a hazardous substance, but also a potential source of contaminants to other media, the characterization of the presence, nature, and extent of NAPL will be another primary objective of the RI. The data needs associated with NAPL include investigation to identify its presence, collection of data to delineate its lateral and vertical extent in the subsurface, and laboratory testing to evaluate its composition and mobility.

The information needed to satisfy these data needs will be obtained by field screening soil, gauging monitoring wells for the presence of NAPL, evaluating chemical data from soil, groundwater, and sediment for indications of NAPL presence, and, if feasible, collecting NAPL samples for physical and chemical testing.

6.2.3 Contaminant Fate and Transport

Contaminants present in Site media may migrate from one location to another via the fluid flow processes of advection or diffusion, transfer between media via partitioning mechanisms, and attenuate as the result of physical, chemical, or biological processes. Contaminants can also be transformed into different chemicals or destroyed by biological or chemical reactions. Understanding contaminant migration and transformation across the Site is important for evaluating potential exposure pathways, anticipating how the nature and extent of contamination may change over time, and evaluating the potential effectiveness of remedial actions, including estimating the restoration time frame. The potential contaminant migration pathways and transformation processes are described in detail in Section 4.2.

To evaluate fate and transport of upland contaminants, it will be necessary to collect data to evaluate potential medium-to-medium migration pathways and NAPL migration pathways (Table 6-1). The data needs associated with the evaluation of upland contaminant fate and transport include data to define the physical characteristics of soil and NAPL, define the physical characteristics of aquifers and aquitards, evaluate natural attenuation and degradation of contaminants in soil and groundwater, and evaluate groundwater chemical data to assess spatial and temporal trends. Information obtained to determine the physical characteristics of the Site (Section 6.2.1) and the nature and extent of contamination (Section 6.2.2) will be used to evaluate contaminant fate and transport. The additional information needed to satisfy these data needs will be obtained by the collection and analysis of groundwater samples for specific indicators of natural attenuation or degradation of contaminants and the evaluation of groundwater data for changes in contaminant concentrations along a chemical flow path.

To evaluate fate and transport of marine contaminants, it will be necessary to collect data to evaluate medium-to-medium migration pathways and NAPL migration pathways. These data needs will be satisfied by an evaluation of surface sediments, surface sediment porewater, subsurface sediments, surface water, and physical characteristics of sediments. In addition, data are needed to characterize the physical mechanisms of transport within the Port Washington Narrows to determine potential transport through surface water, sediment littoral drift, and sediment bed load mobility.

6.2.4 COC Identification

The scope of work for the RI/FS will include collection and analysis of samples for Site COPCs (see Section 4.4) to support the identification of Site COCs, which are those contaminants identified to be present at concentrations that pose a potential risk to human health or the environment in media for which there is a potential complete exposure pathway. The Site COCs will be identified through a comparison of detected chemical concentrations of COPCs to initial PRGs and the results of the human health and ecological risk assessments (Section 6.3). The basis for eliminating a contaminant or contaminant group as a COPC include the following:

- The contaminant is a naturally occurring inorganic compound and is detected within the acceptable range of a documented regional or site-specific background concentration.
- The contaminant is not identified as a COC in the baseline human health or ecological risk assessments (see Section 6.3).

6.2.5 Risk Assessment

The data needs for the risk assessment generally overlap those for the RI and FS. Specific types of information required to support the development of a baseline human health risk assessment (HHRA) and a baseline ERA include the following:

- Upland Areas of Site:
  - Conduct supplemental testing within the upland portion of the ISA to finalize the list of COPCs for the upland area.
  - Determine the nature and extent of contamination in surface soil and subsurface soil to assess risks for human and ecological receptors.
  - Develop sufficient data to estimate potential risks related to the effect of contaminant vapor on indoor air quality, including shallow subsurface soil and/or groundwater quality data or soil vapor data.
  - Determine the nature and extent of contamination in groundwater and determine whether Site groundwater represents a potential future drinking water source.
- Marine Areas of Site:
  - Conduct supplemental testing within historical source areas to confirm the list of COPCs for the marine investigation.
  - Determine the nature and extent of Site-associated PAH contamination in surface sediments.
  - Evaluate potential PAH contamination in surface water within the marine portion of the ISA.
  - Determine the nature and extent of Site-associated PAH contamination in subsurface sediments in the beach area for use in evaluating potential risks for beach construction workers.
  - Assess the partitioning behavior of PAHs in surface sediment to determine whether literature-based partitioning estimates provide a reasonable basis for estimating contaminant concentrations in porewater.

- If warranted, implement contingent bioassay testing and/or sediment porewater testing to augment sediment and porewater data and evaluate potential impacts on benthic infaunal communities.
- If warranted, implement contingent tissue testing of selected species to refine estimates of potential bioaccumulation of contaminants in aquatic species that are harvested by seafood consumers or that serve as prey for higher trophic level ecological receptors.
- Use video surveys to augment available literature regarding the aquatic species that may use the Site and vicinity.
- Use beach surveys to assess the current abundance of clams potentially subject to harvest activities in beach areas near the Site.

Section 6.3 describes how each of the data collection activities will be used in support of the risk assessment activities.

6.3 Risk Assessment Approach and Methodology

Consistent with the AOC, a baseline ERA and HHRA will be performed to support the RI/FS decision-making. The baseline risk assessments will be completed in parallel with the preparation of the Draft RI Report.

The data collection activities associated with the risk assessment will be conducted as part of the Site characterization activities. The planned data collection activities will address the data needs for completion of the risk assessment for all receptors and exposure scenarios identified in Section 4.3.

The specific risk assessment plan for the HHRA is presented in Table 6-3. The risk assessment plan for the baseline ERA is presented in Tables 6-4 and 6-5. The tables provide the following information:

- The receptor to be evaluated;
- The evaluation framework to be used to estimate potential risks for that receptor under the specific exposure scenario;
- The RI data that will be used in support of the risk assessment for the specific exposure scenario; and
- The endpoint and interpretive framework to be used to quantify potential risks.

6.3.1 Risk Assessment Technical Memorandum

An interim deliverable, the Risk Assessment Technical Memorandum, will be used to document the preliminary screening of the collected RI data and provide a detailed description of the methods to be used for the baseline risk assessments. The Risk

Assessment Technical Memorandum will be prepared in conjunction with the Phase 1 Data Report,[18] which is discussed further in Section 7.3.

The Risk Assessment Technical Memorandum will provide the following information identified in Tables 6-3, 6-4, and 6-5:

- The specific data to be used for the evaluation of each exposure scenario;
- Results of preliminary data screenings;
- Statistical approaches (where applicable) to be used to estimate exposure point concentrations for each exposure scenario;
- Description of any models or calculations to be used to estimate exposures, including the following:
    - Methods used to estimate soil vapor and indoor air quality from soil and groundwater data;
    - Source of any biota-sediment accumulation factors to be used to estimate the bioaccumulation of sediment contaminants in aquatic species;
    - Partitioning coefficient values used to estimate porewater quality from bulk sediment data; and
    - Models and parameters used to estimate the total daily intake of contaminants for each receptor.
- Applicable toxicity information and exposure parameters; and
- Current screening levels, benchmarks, and toxicity reference values to be used.

The Risk Assessment Technical Memorandum will also identify any contingent testing activities (if applicable) to be implemented in support of the risk assessment. Any proposed testing activities will be documented in an addendum to the Work Plan in accordance with the AOC (see Section 7.2).

6.3.2 Human Health Risk Assessment

The HHRA methodology will be based on national and regional guidance designated by EPA, including, but not limited to, the following:

- Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, Parts A through F (EPA 1989);
- Interim Guidance: Developing Risk Based Clean-up Levels at Resource Conservation and Recovery Act Sites in Region 10 (EPA 1998a);

[18] In the AOC, this report is also called the RI/FS Data Report.

- The Exposure Factors Handbook (EP
- 2011); and
- The Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia (EPA 2007).

Toxicity data will be developed on the basis of the EPA hierarchy of human health toxicity values (EPA 2003). Any updates to the above sources will be documented in the Risk Assessment Technical Memorandum.

The Draft Baseline HHRA Report will be submitted to EPA 180 days after the receipt of validated data from samples collected during the Site characterization activities. The Final Baseline HHRA Report will be included in the Final RI Report.

6.3.3 Ecological Risk Assessment

The ERA methodology will address both terrestrial and aquatic ecological exposures. The ERA methodology will be based on EPA guidance, including, but not limited to, the following:

- Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, (EPA 1997a)
- Guidelines for Ecological Risk Assessment (EPA, 1998b); relevant and appropriate updated EPA guidance material (e.g., EPA's Eco Updates)
- EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund (EPA 1997b).

Toxicity data will be developed in accordance with EPA guidance (e.g., EcoSSLs) and databases (e.g., Ecotox), peer-reviewed scientific literature, and recent EPA-approved risk assessments. Any updates to the above sources will be documented in the Risk Assessment Technical Memorandum.

The Draft Baseline ERA Report will be submitted to EPA 180 days after the receipt of validated data from samples collected during the Site characterization activities. The Final Baseline ERA Report will be included in the Final RI Report.

6.4 Data Quality Objectives

A seven-step process was used to develop DQOs for data collection, in accordance with EPA guidance (EPA 2006). DQOs designed to address the data needs identified in Section 6.2 are summarized in Tables 6-6 through 6-10. The Site characterization approach is discussed in Section 6.5.

6.5 Site Characterization Approach

This section presents the general approach for characterizing the Site and addressing data gaps related to the upland and marine portions of the Site. Additional details regarding exploration locations, sampling and analysis rationale, and field procedures are provided in the Upland SQAPP (Appendix A) and Marine SQAPP (Appendix B).

6.5.1 Upland Investigation

The locations of the former gas works features and potential source areas shown on the Site base map (Figure 2-3). Some of these features are visible today. The location of the former gas holder is evident as a circular outline in the asphalt. Likewise, there is an expression in the asphalt in the approximate location of the former scrubber. Additionally, a portion of the concrete slab where the coal/coke briquettes were stored is still present and visible at the ground surface. The locations of other former gas works features and other potential source areas will be estimated using field global positioning system (GPS) equipment based on their approximate coordinates obtained from georeferenced historical aerial photographs. As part of this work, additional historical aerial photographs will be obtained from the former Northwest Air Photos collection, if available.

The upland investigation will be conducted sequentially in order to adaptively manage the scope of work to address specific objectives. The geophysical survey and utility locating will be conducted first to identify subsurface features and utilities. The results of the geophysical survey and utility locating will be reviewed in the context of the shallow soil investigation to determine whether additions or modifications to the scope of work are warranted. Likewise, the results of the shallow soil investigation will be reviewed in the context of the deep soil and groundwater investigation to determine whether additions or modifications are warranted. Throughout the investigation, data will be collected to identify and characterize NAPL occurrences, characterize hydrogeology, evaluate contaminant fate and transport, and support the risk assessment. The general rationale and approach for these components of the upland investigation are discussed in the following subsections. For efficiency, as the investigation progresses, the scope of the upland investigation may be modified or expanded on the basis of the field observations and collected data. For example, additional test pits may be completed during the shallow soil investigation to evaluate the lateral extent of contaminants in shallow soil or an additional shallow monitoring well may be installed to evaluate groundwater quality at a source area identified during the shallow soil investigation. If necessary, the decision and rationale for modifying or expanding the scope of the investigation described herein will be discussed with EPA in real-time and documented in the Phase 1 Data Report (Section 7.1).

Depending on the results of the upland investigation, contingent investigations or studies that would require an addendum or addenda to the Work Plan may be warranted. Some potential contingent investigations are described in Section 6.6. The process for planning and reporting on additional phases of investigation work is described in Section 7.2.

6.5.1.1 Geophysical Surveys

Magnetic, electromagnetic (EM) conductivity, and/or ground-penetrating radar (GPR) surveys will be performed to provide information regarding the presence and location of potential buried features. The primary objective of the geophysical surveys is to evaluate the former gas works operations area and the Former Ravine for potential buried structures (i.e., piping, tanks and equipment foundations) or anomalous ground conditions that may indicate historical use of the subsurface use (i.e., covered and filled pits) or fill material. The geophysical surveys will also be used to identify active storm drain lines or other existing utilities.

Magnetic surveys are performed using a magnetometer, which will identify magnetic disturbances due to ferrous iron or steel objects in shallow soils. EM conductivity surveys use an electrical current to evaluate the relative conductivity of the subsurface, which can identify buried metallic objects, variations in lithology that may indicate locations of fill or NAPL, and void space that may indicate buried concrete structures. GPR sends a radar signal – an EM pulse – into the ground. Subsurface objects and soil types cause different signal reflections that are picked up by the receiver. GPR can identify objects deeper in the subsurface than magnetic or EM conductivity surveys under favorable conditions but may have limited effectiveness at the Site because of the dense, fine-grained soils that are present. This information will be used to focus the soil and groundwater investigations to likely source areas.

6.5.1.2 Shallow Soil Investigation

Test pits and shallow direct-push soil borings will be completed in areas that are identified as likely source areas by means of historical information reviews and the results of the geophysical surveys, including all accessible areas of the former gas works operations area and the Former Ravine area (Figure 6-3). The primary objectives of the shallow soil investigation are the following:

- Identify source areas;
- Identify and characterize shallow fill materials;
- Characterize shallow soil lithology;
- Define the lateral extent of COPCs in shallow soil; and
- Investigate the potential for NAPL at source areas and in shallow fill materials.

Because of the density of native glacial soils beneath the former gas works operations area and the suspected presence of buried debris in the Former Ravine, the practical depth of direct-push soil borings is expected to be limited. Additionally, the northern portion of the Sesko Property is not likely to be accessible by a standard direct-push vehicle. Exploration test pits and trenches are likely to be more effective at achieving the primary objectives listed above (Figure 6-3). Direct-push probes will be used in areas where excavation is impracticable (e.g., beneath structures) (Figure 6-3). The shallow soil investigation has been designed to implement the investigation approach that is assumed to be the most successful at meeting the objectives.

Shallow explorations will be completed through fill materials and into native soils if practicable. Direct-push soil borings will be advanced to total depths of approximately 16 feet below ground surface (bgs), which is the depth that is expected to be achievable at most locations by the drilling technology, given the subsurface conditions at the Site. Test pits will be completed to depths of approximately 6 feet bgs. If conditions allow, the test pit depths may be modified in the field if needed to penetrate to native soils, as discussed in more detail in the Upland SQAPP (Appendix A). Soils collected from direct-push borings and test pits will be characterized by soil type and field screened for indications of COPC impacts and NAPL presence (as discussed in more detail in Section 6.5.1.4), and the results will be recorded. Shallow soil samples will be collected for chemical analysis of the COPCs and physical properties testing. The exploration locations for the shallow soil investigation are shown on Figure 6-3; additional details regarding to the sampling approach are discussed in detail in the Upland SQAPP (Appendix A).

The shallow soil investigation will include an evaluation of the origin and location of any historic subsurface piping and the potential of any such piping to be a source of contamination. Historic/abandoned piping that is identified or discovered during the geophysical surveys or the test pit excavations will be investigated by excavation and removal. The piping will be excavated and removed from the ground to a practicable extent, which may correspond to subsurface limitations (i.e. a building foundation), an aboveground structure, the upland ISA boundary, a depth beyond which an exploration excavation is no longer feasible without structural support or shoring, or other practicable limits. If further investigation into piping location is warranted beyond practicable excavation limits, other methods may be employed to meet the investigation objectives (i.e. utility location, GPR surveys, etc.). The decision to excavate piping and/or employ other methods of investigation will be made in consultation with EPA. Soil samples will be collected from beneath the piping at regular intervals, in lengths no greater than 20 feet, and the soil beneath and surrounding the piping will be field screened for indications of contamination. If piping remains in place beyond the feasible extent of removal, the end will be capped and sealed, and the GPS coordinates of its location will be recorded for future reference. If the origin of the piping remains unclear at the limits of feasible removal, a camera survey or further geophysical survey may be conducted in an attempt to identify its origin and historic use.

The piping connected to Manhole A will be investigated in the same manner. Manhole A is currently filled with concrete debris and dirt, which is unlikely to be successfully removed without the removal of the manhole structure itself. Therefore, the shallow soil investigation will include the removal of Manhole A, identification and camera survey of any inlets identified, and collection of soil samples from the sidewalls and base of the excavation completed in the process of removing the manhole. Solid materials from inside the piping may be collected, if encountered, for chemical analysis to evaluate the former use of the pipe.

Additional borings or test pits may be advanced if needed to fill data gaps and achieve the DQOs (i.e., if the extent of contamination cannot be determined on the basis of the collected data). The need for additional explorations may be identified in the field (e.g., based on field screening observations) or after laboratory data are received. Field observations and preliminary laboratory data will be reviewed in real time with EPA to determine whether additional explorations are necessary to meet the study objectives.

6.5.1.3 Deep Soil and Groundwater Investigation

The deep soil and groundwater investigation will follow the shallow soil investigation and will be conducted to meet the following primary objectives:

- Characterize deep soil lithology;
- Determine the vertical extent/thickness of fill material along the shoreline and in the Former Ravine;
- Identify and characterize water-bearing zones and aquitards;
- Define the lateral and vertical extent of COCs in soil and groundwater;

- Investigate the potential presence of and characterize the extent of LNAPL; and
- Investigate the potential presence of and characterize the extent of DNAPL.

Deep soil borings, some of which will be completed as monitoring wells, will be advanced using sonic or hollow-stem auger drilling methods (Figure 6-4).

Based on previous investigations, the shallow water table is estimated to be located at approximately 35 feet bgs. Additional monitoring wells will be installed at the water table to evaluate the nature and extent of COPCs in groundwater. Deeper groundwater conditions will be evaluated by the installation and sampling of monitoring wells at deeper intervals within the water table aquifer and/or within a second, deeper aquifer, depending on the Site conditions encountered in the field. The deep soil and groundwater investigation will consist of the following elements, which are discussed in detail in the Upland SQAPP (Appendix A):

- Completion of three initial deep borings (MW-101-X, MW-102-X, and MW-103-X; Figure 6-4) at the top of the shoreline bluff using sonic drilling methods. These borings are primarily intended to characterize the subsurface lithology and identify water-bearing units and aquitards. Deep monitoring wells will be installed in the borings, either at the base of the water-bearing zone/top of a competent aquitard or 20 feet beneath the deepest field indication of contamination if an aquitard is not identified. Additional details related to the decision criteria for well construction are provided in the Upland SQAPP (Appendix A).
- Installation of seven additional water table wells (MW-9WT to MW-15WT; Figure 6-4) to the east, south, and west of the former gas works operations area to evaluate groundwater quality, flow direction, and gradient at the water table.
- Installation of one deep well (MW-104-X; Figure 6-4) at the top of the shoreline bluff to evaluate deep groundwater quality.
- Installation of one deep well (MW-105-X; Figure 6-4) in the Former Ravine fill area on the Sesko Property to evaluate deep groundwater quality.
- Installation of approximately four additional water table wells, at locations to be determined according to the results of the shallow soil investigation, in areas of the McConkey Property and/or the Sesko Property where potential sources are identified in the shallow soil investigation.

After the installation and development of all water table and deep wells, groundwater samples will be collected for chemical analysis to evaluate the lateral and vertical distribution of COPCs in groundwater. In additional, all wells will be evaluated for the potential presence of NAPL, as discussed in Section 6.5.1.4.

Additional borings or wells may be installed if needed to fill data gaps and achieve the DQOs (i.e., if the extent of contamination cannot be determined on the basis of the collected data). The need for additional explorations may be identified in the field (e.g., based on field screening observations) or after laboratory data are received. Field observations and preliminary laboratory data will be reviewed with EPA to determine the need for additional explorations to meet the study objectives.

6.5.1.4 NAPL Identification and Characterization

NAPLs include both LNAPL, when the density is less than that of water (i.e., it will float on water), and DNAPL, when the density is greater than that of water (i.e., it will sink in water). If there is sufficient volume and the soil is sufficiently permeable, both LNAPL and DNAPL will migrate downward via gravity flow through the soil. Because it is less dense than water, LNAPL will begin to migrate laterally when it encounters groundwater, primarily in the direction of groundwater flow. DNAPL is denser than water and will continue to sink below the water table. As it migrates downward, both in the vadose zone and through the water-bearing zone, NAPL leaves behind a residual coating of product on the soil grains, which can be used as an indicator of the potential presence of NAPL.

DNAPL will continue to migrate downward via gravity flow until the available volume of mobile DNAPL has been depleted or until a soil layer with lower permeability is encountered. DNAPL may collect in pools on top of low-permeability layers and migrate laterally through seams of higher permeability soil. Downward vertical migration of DNAPL below the water table can also be slowed or eliminated by an upward hydraulic gradient. Along with the evaluation of the presence of NAPL, the geologic and hydrogeologic conditions at the Site will be characterized as part the evaluation of potential NAPL mobility.

Both LNAPL and DNAPL may be present at the Site. Potential LNAPL materials include gasoline- and diesel-range petroleum used as feedstocks and light oils produced during the manufactured gas process. Potential DNAPL materials include tars produced during the manufactured gas process. The DNAPL tars from carbureted water-gas production are referred to as carbureted water-gas tars, which are similar to other types of tars associated with gas manufacturing in that they contain significant quantities of aromatic compounds; however, they are almost completely devoid of the tar acids commonly found in coal tars, and they contain more sulfur (Birak and Miller, 2009).

The investigation into the presence of NAPL at the Site and the evaluation of the extent of NAPL will be conducted using the following methods:

- **Field Screening of Soil Samples.** Soil samples collected from shallow explorations (test pits/trenches) and shallow and deep soil borings will be field screened for the presence of NAPL. Potential NAPL presence is indicated by observations of oil, tar, product, or heavy sheen.
- **Accumulation of NAPL in Monitoring Wells.** The liquid levels in monitoring wells will be gauged using equipment that distinguishes between aqueous and non-aqueous liquids to identify and measure accumulation of NAPL in monitoring wells. In addition, groundwater samples collected from the wells will be visually inspected for the presence of separate-phase liquids.
- **Reported Chemical Concentrations That May Indicate NAPL.** The reported chemical concentrations of benzene, naphthalene, and PAHs will be used in conjunction with field screening and NAPL accumulation in monitoring wells to identify potential NAPL occurrences. Concentrations of hydrocarbons in soil greater than 10,000 mg/kg generally indicate the potential presence of tar or NAPL (Cohen and Mercer 1993). The detection of benzene, naphthalene, or PAHs in

groundwater at a concentration greater than 10 percent of each contaminants' solubility suggests that NAPL may be present at or upgradient of that location.

If NAPL is identified and recoverable, samples will be collected to characterize the properties that affect mobility and migration in the subsurface by laboratory testing of specific gravity and viscosity. Additionally, the chemical composition of the NAPL will be determined by analytical testing.

Contingent investigations to further evaluate NAPL may be conducted, as described in Section 6.6.

6.5.1.5 Fate and Transport Evaluation

The data collected for the RI will inform the evaluation of contaminant transport within and between environmental media and evaluate potential mechanisms for contaminant attenuation. Physical soil characteristics, including soil type, grain size, density, and TOC content, will be evaluated to support the analysis of migration pathways including the potential for contaminants to leach from soil into groundwater and to sorb to soil from groundwater. Hydraulic characteristics, including hydraulic conductivity, groundwater gradients, and tidal influences, will be determined to evaluate groundwater flow and associated contaminant transport. Groundwater geochemical data will be collected to evaluate contaminant attenuation. Soil and groundwater chemical data, along with physical characteristics, will be used to evaluate potential migration pathways to soil vapor and indoor air.

6.5.2 Marine Investigation

The elements of the marine investigation are summarized in Table 6-16 and include the following:

- **Video Surveys.** Video surveys will be conducted to identify substrate, habitat characteristics, and presence/abundance of aquatic resources near the Site.
- **Surface Sediment Investigation**. Surface sediments will be sampled and analyzed as follows:
  - o Within the ISA to define the nature and extent of Site-related COPCs. A subset of samples will be analyzed for an expanded list of analytes, including cyanide (total and available), metals and SVOCs, to finalize, in consultation with EPA, the list of contaminants for inclusion in the surface sediment sampling program.
  - o Beyond the ISA to assess the quality of sediment within the Port Washington Narrows that could potentially contribute to recontamination of the Site following implementation of the cleanup action.
  - o Analyze paired samples of bulk sediment and pore-water from within the ISA and within Port Washington Narrows to determine how actual PAH leaching compares with leaching estimated using literature-derived partitioning coefficients.
- **Subsurface Sediment Investigation.** Subsurface sediment core samples will be collected from the beach and subtidal areas sloping down into the Port Washington

Narrows to evaluate the vertical distribution of Site-related COPCs (including the potential presence of NAPL and hydrocarbon sheen) in subsurface sediments.

- **Beach Shellfish Surveys.** Beach surveys will be performed to evaluate the distribution of existing shellfish resources within and near the beach areas adjacent to the Former Gas Works Property and within comparable beach areas within Port Washington Narrows.
- **Surface Water Investigation.** Surface water samples from selected Site and background locations will be collected and analyzed during multiple sampling events to assess potential variability in the concentrations of contaminants in surface water.
- **Tidal Current Evaluation.** Near-bottom tidal currents within the aquatic areas of the Site will be monitored to assist in the evaluation of sediment stability.

Some elements of the marine investigation will be conducted sequentially in order to adaptively manage the scope of work. Surface sediment sampling will be conducted first to determine the lateral extent of contamination and will be evaluated to determine whether modifications to the subsurface scope of work are required before implementation. Other elements of the scope of work, such as the surface water, tidal current, and beach shellfish survey, will not be sequential. The general rationale and approach for these components of the marine investigation are described in the following subsections, and the details are included in Appendix B. Based on the results of the marine investigation, contingent investigations or studies may be warranted; those are described in Section 6.6.

6.5.2.1 Video Survey

Towed camera video surveys will be conducted to allow for a relative comparison of environmental conditions within and adjacent to the Site. The objective of the surveys is to identify substrate types, habitat characteristics, and the presence/abundance of aquatic resources. The video surveys will be collected along 12 predefined transects in the Port Washington Narrows in the vicinity of the ISA (Figure 6-5). Six transects each will be conducted perpendicular to and parallel with the shoreline of the Port Washington Narrows. The parallel video transects are positioned at the southern and northern shores at the -10 feet mean lower low water (MLLW) and -20 feet MLLW contours (Figure 6-3), through the deeper channel area adjacent to the former gas works, and over the shallower area in the central channel. One of the perpendicular transects is positioned through the slope adjacent to the former gas works and two are positioned to the east and west in the Port Washington Narrows. After the video surveys are complete, the locations of the transects will be plotted on a figure. The videos will be reviewed to qualitatively determine the substrate type, habitat characteristics, presence/abundance of aquatic resources, and any other significant observations, and the results will be logged. This survey will yield an interpretative figure, which will present the video survey findings

6.5.2.2 Surface Sediment Investigation

Surface sediment samples will be collected to characterize the lateral nature and extent of Site-related contamination, evaluate chemical fate and transport, determine COPCs, and evaluate relative bioavailability of Site-related contamination. All surface sediment samples will be collected from a depth 0 to 4 inches below the mudline that typically constitutes the bioactive zone. Consistent with previous Site-related investigations, intertidal sediment samples will be collected by hand during low tide. All subtidal surface sediment samples will be collected using a power actuated Van Veen grab sampler. The surface sediment samples will be tested for alkylated PAHs and physical properties such as TS, TOC, and grain size.

The surface sediment adjacent to the Former Gas Works Property will be characterized with the use of 17 sampling locations along transects down the slope toward the Port Washington Narrows channel and 2 sampling locations immediately west of the slope within the marina (Figure 6-6). These 19 sampling locations are collocated with the locations in which subsurface cores will be collected for vertical delineation (see 6.5.2.3). Surface sediment samples collected from all of the intertidal sample locations will be submitted for expanded analytical testing of COPCs including total and available cyanide, metals, and SVOCs. In addition, samples from five of these locations will be tested to determine the relative bioavailability of PAHs by *ex situ* solid-phase microextraction (SPME) testing of porewater (Figure 6-8).

Additional surface sediment samples will be collected to characterize the nature and extent of contamination of surface sediment within the ISA. These samples will include a sample from the marina to the west, two intertidal locations to the east, four subtidal locations at the base of the slope, and seven subtidal locations distributed throughout the ISA.

Surface sampling outside the ISA is needed to supplement available sediment quality data within the Port Washington Narrows. A total of 16 locations are proposed within the littoral drift zones and channel of Port Washington Narrows (Figure 6-7). A subset of five locations will be submitted for *ex situ* SPME testing to determine the relative bioavailability of PAHs in porewater (Figure 6-7). Data from these porewater samples will be paired with associated bulk sediment and TOC data to determine how actual PAH leaching compares with leaching estimated using literature-derived partitioning coefficients.

6.5.2.3 Subsurface Sediment Investigation

Subsurface core sampling will be conducted to determine the vertical nature and extent of Site-related COPCs (including NAPL and sheen). The subsurface explorations will be advanced at 17 sampling locations along transects aligned down the slope from the Former Gas Works Property and at 2 locations immediately west of the slope within the marina (Figure 6-7). The subsurface sampling area includes the intertidal areas where with Site-related COPCs are known to be elevated and in locations of historical dock structures. As designed, the core sampling program is of sufficient density to evaluate migration pathways described in Section 4.2.1. To evaluate potential release pathways to the Port Washington Narrows, the deepest core in each transect targets the -20 feet MLLW elevation to acquire subsurface sediments below the approximate elevation of the channel depth of -25 feet MLLW.

At each location, a 15-foot-long vibracore will be advanced until it can penetrate no further. Each core will be logged and sectioned into 1- or 2-foot intervals for testing based on visual observation and stratigraphy. Initially, two subsurface core intervals will be submitted for analysis of TS, TOC, grain size, and PAHs. All remaining core intervals will be archived for future analysis, if needed. If NAPL is identified during the processing of cores collected at the subsurface core locations, additional cores will be advanced as determined in coordination with the EPA during the planned field investigations.

The planned subsurface investigation will be completed using vibracore exploration methods. To the extent that the findings of upland and sediment investigations indicate that Site-related contamination is likely to be present in sediment strata that could not be evaluated using these sampling methods, other sampling approaches will be considered. If alternative methods (e.g., use of barge-mounted auger drilling methods) are warranted, then the methods and locations for such follow-up investigations would be defined in an addendum to the Work Plan (see Section 7.2).

6.5.2.4 Beach Shellfish Surveys

Beach shellfish surveys will be conducted to document the types and quantities of potentially harvestable shellfish species currently present within the ISA and adjacent areas of Port Washington Narrows. The surveys will be conducted at 5 locations within the ISA and 11 locations within the Port Washington Narrows (Figure 6-6 and Figure 6-8) in accordance with WDFD methods (Campbell, 1996). These data will be used to inform estimates of sustainable shellfish yield for use in developing the baseline risk assessment.

6.5.2.5 Surface Water Investigation

Surface water samples will be collected from within the ISA and at background locations to analyze the concentrations of Site-related COPCs (Figure 6-7). These data will be used to inform the HHRA and ERA. To assess potential variability associated with seasons and weather conditions, four quarterly sampling events will be conducted. One of the sampling events will target a rain event, and another will target a relatively dry period. At each location, samples will be collected from 3 feet below the water surface and 3 feet above the mudline. The surface water samples will be submitted for an analysis of conventional parameters (total organic carbon, dissolved organic carbon and total suspended solids) and alkylated PAHs. Field measurements of dissolved oxygen, pH, salinity, and temperature will be recorded at each sampling depth.

6.5.2.6 Tidal Current Evaluation

Tidal current surveys will be conducted by a qualified contractor along transects at the locations shown on Figure 6-5. A vessel-mounted acoustic Doppler current profiler will be used to measure current velocity along transects over the course of a daily tide cycle with a relatively high tidal exchange. Sampling will be performed during a period of high tidal exchange (between a high tide of at least mean higher high water and a low tide below mean lower low water). Measurements will be collected in both directions (i.e., back and forth) across each transect location to decrease any directional bias in the data. Results from near-bottom measurements within the ISA will be used to inform the FS and assess the potential impacts of tidal currents on sediment stability.

6.6 Contingent Studies

Other studies in addition to those described in Sections 6.4 and 6.5 may be necessary to characterize the Site for the RI/FS. However, the need and scope of these studies will depend on the results of the initial studies. A number of these potential contingent studies are described in Sections 6.6.1 and 6.6.2.

6.6.1 Upland Investigation

Contingent upland investigation activities may be warranted to fill remaining data gaps after completion of the work described in Section 6.5.1. These contingent investigation tasks may include the following:

- Additional investigation into the nature of NAPL, if determined to be present, by applicable petrophysical testing methods;
- Additional investigation into the extent of NAPL, if determined to be present, by applicable *in-situ* and/or *ex-situ* characterization techniques;
- Sampling of soil vapor and/or indoor air, if collected data indicate a potential risk to existing permanent, heated structures; and
- Development of hydraulic and/or contaminant fate-and-transport groundwater models.

The scope of and methods for these studies, if needed, will depend on the results of the initial investigations and are, therefore, not provided in this Work Plan. An addendum to the RI/FS Work Plan would be prepared if additional studies are needed. A brief description of potential contingent activities is provided below.

If NAPL is present at sufficient volumes in any wells, bail-down tests may be used to estimate the transmissivity of DNAPL and LNAPL. Other petrophysical testing methods may also be applicable, depending on the type, quantity, and location of NAPL identified during the RI.

The TarGOST® technology, which uses laser-induced fluorescence to delineate coal tar or creosote NAPL (moderate to heavy concentration of PAHs), could possibly be used to detect and characterize NAPL in fill and shallow native soils in areas where coal tar or creosote has been identified by other investigation methods. However, TarGOST® is specifically intended for use in delineating NAPL-contaminated zones and is appropriate for sites where there is a confirmed presence of coal tar or creosote NAPL. In addition, TarGOST® is conducted using direct-push drilling methods that likely have limited depth penetration capabilities at the Site due to the dense glacial soils. A preliminary understanding of the extent to which NAPL is present in shallow or deeper soils at the Site, and a better understanding of the nature of subsurface soils at the Site is needed to determine whether the use of TarGOST® could be successful at the Site.

Ultraviolet (UV) light photography could be used to characterize NAPL occurrence and extent with low to moderate concentrations of PAH components. The technique uses a digital image of a soil core in an area of known or suspected NAPL to evaluate the nature of the NAPL, such as its pore space saturation and its potential mobility. UV light photography can also determine the relative impacts within a single core to identify the most heavily impacted zone and identify variation in NAPL impacts between soil lithologies within the core.

Hydraulic and/or contaminant transport groundwater models may be useful tools for conducting the RI and FS. These tools can be used in conjunction with empirical data to further the understanding of contaminant fate and transport and support the engineering evaluations of remedial technologies such as groundwater pumping. However, additional Site information is needed to evaluate the usefulness of these tools and which models might be appropriate.

As discussed in Sections 7.1 and 7.2, any contingent work activities will be proposed on the basis of the data gaps identified in the Phase 1 Data Report. The scope of work and sampling methodology for the contingent upland investigation would be described in detail in an RI/FS Work Plan addendum (Section 7.2), which would be approved by EPA before the completion of any additional work.

6.6.2 Marine Investigation

Contingent sediment investigation activities may be warranted to fill remaining data gaps after completion of the work described in Section 6.5.2. These contingent investigation tasks may include the following:

- Potential step-out surface or subsurface sampling in the sediment areas of the Site, if needed to define the nature and extent of Site-related contamination.
- Supplemental subsurface sediment coring using alternative methods, if needed, to evaluate the distribution of Site-related contamination not accessible using vibracore methods.
- Sediment bioassay and/or porewater testing, if necessary to confirm the estimated extent of benthic infaunal community impacts for the ERA.
- Testing of Site-related contaminant concentrations in tissues in relevant seafood species or prey species if necessary to support the HHRA or ERA.
- Sediment geochronology testing, if it is determined necessary to support the evaluation of sediment stability and natural recovery processes.

The scope of and methods for these studies, if needed, will depend on the results of the initial investigations and are, therefore, not provided in this Work Plan. An addendum to the RI/FS Work Plan would be prepared if additional studies are needed (see Section 7.2).

7 Remedial Investigation and Feasibility Study Tasks

This section provides a general description of the tasks to be performed to complete the RI and FS in accordance with the AOC, the SOW and EPA RI/FS guidance (EPA 1988a). It also summarizes the various phases of work and how each phase relates to the next phase. A general schedule for completion of the work is provided in Section 8. Specific details of field investigation methods and sampling approaches, as currently planned, are provided in Appendix A.

7.1 Planned Remedial Investigation Activities

The planned work activities, as described in Section 6.5, will be completed to meet the objectives of the RI/FS in accordance with the requirements of the SOW. The collection of data will address the data needs to assess the current and future potential risk to human health and the environment and allow for the development and screening of remedial action alternatives. The planned work activities, presented herein, are those anticipated to be necessary to meet the RI/FS objectives, which are further specified in the SOW:

- Investigate and define the physical, chemical, and biological characteristics of the Site;
- Define the sources of contamination;
- Define the human and ecological uses of Site; and
- Describe the nature and extent of contamination.

Collected data will be provided to EPA as it is received to enable adaptive management practices in evaluating whether the RI/FS objectives have been met. Data may be provided in tabular or visual form as needed to support work planning.

After the completion of the work activities described in this Work Plan, the Phase 1 Data Report will be prepared to compile the collected data. In accordance with the SOW, the Phase 1 Data Report will describe and display information and data collected during the Site characterization activities, including the sampling locations and the distribution of contaminant concentrations. If data needs are identified that require activities not covered by this Work Plan, one or more Work Plan Addenda may be prepared (see Section 7.2).

7.2 Contingent Remedial Investigation Activities

If determined to be necessary to satisfy outstanding data needs and meet the objectives of the RI/FS, contingent studies will be proposed in one or more RI/FS Work Plan addenda. The contingent studies may consist of the expansion of previous studies, potential contingent studies identified in Section 6.6, or other studies that are warranted based on the collected data. Work Plan addenda will be submitted, if applicable, with the Phase 1 Data Report, if applicable. If warranted, each Work Plan addendum will present the proposed scope of work, including the basis for the additional work and the rationale for the sampling locations and/or methodology.

Data collected during contingent studies will be documented and submitted to EPA in the Phase 2 Data Report.

7.3 Risk Assessment

The RI/FS will include collection of information and data necessary to perform a baseline HHRA and ERA, in accordance with the SOW (EPA, 2013a). The risk assessment will consider current and potential future land uses at the Site, taking into account local land use designations applicable to the Former Gas Works Property and the Sesko Property. The scope and key elements of the HHRA and ERA are described in Section 6.3. A Risk Assessment Technical Memorandum will be prepared in conjunction with the Phase 1 Data Report to present the preliminary screening of the RI data and provide a detailed description of the methods to be used for the baseline risk assessments. The Risk Assessment Technical Memorandum will be submitted to EPA for concurrence that sufficient data has been collected, or to propose the collection of additional data, to enable preparation of the draft baseline HHRA and ERA.

The draft reports for the baseline HHRA and ERA will be submitted to EPA as part of the Draft RI Report (Section 7.4). After EPA has reviewed the Draft RI Report and provided comments, the final risk assessment reports will be submitted to EPA with the Final RI Report (Section 7.4).

7.4 Remedial Investigation Report

After the completion of any contingent studies and EPA approval of the data report summarizing the final phase of investigation (either the Phase 1 Data Report or a Phase 2 Data Report), a Draft RI Report will be prepared to summarize the results of all phases of the field activities conducted to characterize the contaminant sources, evaluate the nature and extent of contamination, and evaluate the fate and transport of contaminants. The Draft RI Report will be submitted to EPA for review in accordance with the requirements of the AOC. After the receipt of EPA comments, a Final RI Report will be prepared.

7.5 Remedial Alternatives Development/Screening

The first step in the FS process will be the preparation of an Alternatives Development Memorandum that identifies and screens a range of potential remedial alternatives in order to determine whether they should be included in a more detailed analysis. The Alternatives Development Memorandum will include the following:

- Identification of refined RAOs based on the results of the RI and baseline risk assessments;
- Development of general, potential response actions for each medium of interest to meet the RAOs;
- Identification of areas and volumes of Site-related COPCs to which the general response actions may apply;
- Identification and evaluation of remedial technologies applicable to each general response action and a screening to determine and document those that will be eliminated from further evaluation;

- A presentation of the selected remedial technologies and their assembly into remedial action alternatives for the Site;
- A summary of the action-specific and contaminant-specific ARARs and PRGs for each of the assembled remedial action alternatives;
- A screening of the assembled remedial action alternatives based on short- and long-term effectiveness, implementability, and relative cost, if necessary.

The Alternatives Development Memorandum will be prepared after EPA approval of the Final RI Report.

7.6 Treatability Study/Pilot Testing

Treatability studies and/or pilot testing of potential remedial technologies will be performed after the preparation of the Alternatives Development Memorandum, if necessary to support further evaluation of the retained alternatives. If treatability studies or pilot testing are determined to be necessary to evaluate a particular technology, a Treatability Testing Work Plan will be prepared to describe the technology, present the purpose of the treatability study/pilot testing, and summarize the testing approach and methodology, including a Sampling and Analysis Plan, if appropriate. The results of the treatability study/pilot testing will be summarized in a Treatability Study Evaluation Report, which will be submitted to EPA as a draft for review and comment; any comments provided by EPA will be addressed in a final version of the report.

7.7 Detailed Analysis of Alternatives

A detailed analysis of the final set of alternatives (Section 7.5) and the results of any treatability studies and/or pilot testing (Section 7.6) will be performed. It will consist of an analysis of each alternative in terms of nine CERCLA evaluation criteria (EPA 1998a) and a comparative analysis of all of the alternatives using the same criteria as a basis for comparison. The results will be documented in an Alternatives Evaluation Memorandum.

7.8 Feasibility Study Report

After the receipt of EPA comments on the Alternatives Evaluation Memorandum, the Draft FS Report will be prepared to present the basis for remedy selection and document the development and analysis of the remedial alternatives. The Draft FS Report will be submitted to EPA for review in accordance with the requirements of the AOC. After the receipt of EPA comments, a Final FS Report will be prepared.

8 Schedule

The field investigation activities described herein will commence within 30 days after receipt of EPA's written approval of the Final RI/FS Work Plan. The estimated schedule and sequencing of field investigation activities is provided in Table 8-1. The actual schedule may vary based on a number of factors including contractor availability, the date EPA approves the Final RI/FS Work Plan, and adjustments to the scope of work based on field investigation findings. Table 8-1 identifies decision points at which preliminary investigation data are evaluated to confirm or adjust subsequent phases of investigation. The schedule for completing the RI/FS Work Plan investigation activities will be consistent with the deadlines defined in the AOC, which include the following:

- Prepare and submit the Phase 1 Data Report to EPA within 90 days after completion of Site characterization activities and receipt of final validated data. The Phase 1 Data Report will summarize the results of the Site characterization activities and identify any outstanding data needs.
- If warranted by the results summarized in the Phase 1 Data Report, prepare a Work Plan addendum describing the additional Site characterization activities necessary to meet the objectives of the RI/FS. After EPA approval of the Work Plan addendum, complete the additional Site characterization activities.
- Prepare and submit a Phase 2 Data Report to EPA within 90 days after completion of the additional Site characterization activities and receipt of final validated data. The Phase 2 Data Report will summarize the results of the additional Site characterization activities.
- The Draft Baseline Ecological and Human Health Risk Assessment Reports will be prepared and submitted to EPA within 180 days after receipt of all final validated data obtained during Site characterization activities, including any contingent studies.
- The Draft RI Report will be prepared and submitted to EPA within 360 days after receipt of all final validated data obtained during Site characterization activities, including any contingent studies.
- The Final RI Report, which will include the Final Baseline Ecological and Human Health Risk Assessment Reports, will be submitted to EPA within 90 days after receipt of comments from EPA on the Draft RI Report.
- The Alternatives Development Memorandum will be submitted to EPA within 90 days after receipt of EPA's written approval of the Final RI Report.
- If necessary, a Treatability Testing Work Plan, treatability testing, and the Treatability Study Evaluation Report will be completed to further evaluate alternatives introduced in the Alternatives Development Memorandum. A separate schedule will be prepared for these activities if they are deemed necessary.

- The Alternatives Evaluation Memorandum will be submitted to EPA within 90 days after receipt of EPA's comments on the Alternatives Development Memorandum and Treatability Study Evaluation Report, if applicable.
- The Draft FS Report will be submitted to EPA within 120 days after receipt of EPA's written approval on the Alternatives Evaluation Memorandum.
- The Final FS Report will be submitted to EPA within 60 days after receipt of comments from EPA on the Draft FS Report.

9 Project Management Plan

This section identifies key project staff and responsibilities and describes lines of communication and project coordination details. It also includes a description of data management procedures.

9.1 Project Management

The RI/FS is being conducted by Cascade. EPA is providing regulatory oversight of the RI/FS activities in accordance with the AOC. The designated project managers are listed below.

The Remedial Project Manager (RPM) for EPA is:

William Ryan
EPA Region 10, Office of Environmental Cleanup (ECL-113)
1200 Sixth Avenue
Seattle, Washington 98101
Phone: (206) 553-8561
E-mail: Ryan.William@epa.gov

The Project Coordinator for Cascade is:

Kalle Godel
Montana-Dakota Utilities Co.
400 North Fourth Street
Bismarck, North Dakota 58501
Phone: (701) 222-7657
E-mail: Kalle.Godel@mdu.com

The Cascade Project Coordinator is responsible for administering the actions required by the AOC.

Cascade's consultant project team consists of representatives from Aspect and AnchorQEA and their subconsultants and subcontractors. Aspect will be coordinate RI/FS activities for the upland area of the Site. Anchor QEA will coordinate RI/FS activities in the marine area of the Site and conduct the risk assessment. Aspect will be responsible for overall project management and production of RI/FS deliverables.

The project managers for Aspect and Anchor QEA, who have final authority and responsibility for their teams' activities, are as follows:

- **Aspect:** Jeremy Porter
- **Anchor QEA:** Mark Larsen

Supporting project team members and team management structure for conducting the Site characterization activities described in this Work Plan are provided in the Upland and Marine SQAPPs (Appendices A and B).

All work will be conducted in accordance with the consultants' Quality Management Plans, which have been previously submitted to EPA in accordance with Section VIII of the AOC.

All work conducted by Aspect and Anchor QEA will be completed in accordance with applicable state and federal worker health and safety requirements. The site-specific Health and Safety Plans for each organization, which establishes the procedures and practices to protect their workers from potential hazards posed by field activities at the Site, are included as Appendices G (Aspect) and H (Anchor QEA).

9.2 Project Communications

Periodic communications between the RPM, the Project Coordinator, and the consultants are conducted to minimize delays and to facilitate identification and resolution of potential problems. Project communications include:

- **Progress Reports.** In accordance with the AOC, quarterly progress reports are due to EPA by the 15th day of the month following each quarter. The current schedule involves submittal of progress reports by January 15th, April 15th, July 15th, and October 15th of each year.

- **Meetings and Teleconferences.** In accordance with the AOC, monthly status calls or meetings are conducted with EPA, unless EPA and Cascade agree to cancel or postpone. Additional meetings and teleconferences are conducted on an as-needed basis. The RI data collection schedule (see Section 8) includes several meetings or teleconferences as decision steps in evaluating preliminary investigation data and confirming or adjusting the scope of subsequent data collection efforts. Additional meetings or teleconferences may be held with EPA in presenting initial findings of the RI/FS and risk assessment, evaluating data evaluation approaches, assessing data gap fulfillment, and reviewing deliverables.

- **Stakeholder Briefings.** In accordance with the AOC, periodic briefings on the work will be coordinated with EPA and project stakeholders.

- **Notifications.** In accordance with the AOC, Cascade will notify EPA a minimum of two weeks prior to planned field activities.

9.3 Data Management

Considerable quantities of data have already been obtained and will be collected during the RI field investigation. This data will need to be stored, checked for quality, and presented in reports. This section outlines how these data will be managed.

Software and procedures are in place to effectively and efficiently handle data generated during the RI. These systems and processes will ensure that data (e.g., sample numbers, methods, qualifications, locations, etc.) are readily accessible and accurately maintained. The primary steps/elements in the data management process are:

- EarthSoft EQuIS 6 environmental chemistry database setup
- gINT geological boring log database setup
- Sample and analysis planning
- Sample collection
- Field measurements
- Documentation of location of field activities (GPS, survey, etc.)
- Laboratory analytical data management
- Preliminary reporting and data QA/QC
- Formal data validation (details provided in the SQAPPs) and associated database updates
- Development of maps and tables from EQuIS database, integrated with GIS software as appropriate, to support RI/FS reporting requirements
- Analytical data submittals in accordance with USEPA's Region 10 Data Submission Process for WQX Compatible Deliverables
- Geographic Information Systems (GIS) data submittals in accordance with U.S. EPA Region 10 GIS Data Deliverable Guidance (ed. March 2013)

Data will be collected and recorded in a variety of ways during this project. These include standard field forms (e.g., field data sheets, chain-of-custody forms, and boring logs) and laboratory-generated analytical data. Information about exploration locations, samples, laboratory tests, field measurements and analytical results will be maintained in an EarthSoft EQuIS 6 database. These data will be loaded to EQuIS from electronic data deliverables (EDDs) and preliminarily checked for completes and fidelity against associated reports and documentation. Lithological data will be entered into the gINT database from boring logs under supervision by professional geologists. Access to the EQuIS and gINT databases will be limited to trained project personnel, and the ability add or change data will be granted to only those trained, professional data managers, chemists, and geologists.

Lab reports and other source documents (including original laboratory EDDs) will be filed electronically according to the project-specific storage and retention policies. All electronic data (including the EQuIS and gINT databases) will be backed up nightly in accordance with industry practices.

Data validation will be performed in accordance with the project SQAPPs. Data validation reports will be filed electronically (along with other source documents) and any associated updates to analytical data (including qualifiers and other validation notes) will be added/updated in EQuIS, as appropriate.

10 References

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TABLES

Table 2-1 - Monitoring Well Construction Information and Groundwater Elevation Measurements

Bremerton Gas Works Site
Bremerton, Washington

Well Identification	Installed By	Date Installed	Surface Elevation (Datum Unknown)	Total Boring Depth (Feet)	Depth to Top of Screen (Feet)	Depth to Bottom of Screen (Feet)	Depth to Water (feet below TOC) 1-Jun-07	Groundwater Elevation (feet NAVD 88) 1-Jun-07
MP-04	E&E	5/13/2008	12.38	40	30	40	--	--
SP-02	E&E	5/12/2008	10.44	35	25	35	--	--
			Surface Elevation in feet (NAVD 88)					
MW-1	GeoEngineers	5/21/2007	45.03	46.5	30	45	34.68	10.35
MW-2	GeoEngineers	5/21/2007	42.54	46.5	30	45	35.25	7.29
MW-3	GeoEngineers	5/22/2007	39.1	46.5	30	45	32.9	6.2
MW-4	GeoEngineers	5/23/2007	35.2	41.5	20	40	29.32	5.88
MW-5	GeoEngineers	5/24/2007	18.51	21.5	5	20	15.21	3.3
MW-6	GeoEngineers	5/22/2007	34.95	36.5	15	35	30.2	4.75
MW-7	GeoEngineers	5/23/2007	33.24	36.5	15	35	30.21	3.03
MW-8	GeoEngineers	5/22/2007	35.56	41.5	20	40	32.64	2.92

Notes:
-- = not measured
E&E = Ecology and Environment
NAVD 88 = North American Veritcal Datum of 1988
TOC = top of casing

Table 3-1 – Potential ARARs, Chemical-Specific

Bremerton Gas Works Site
Bremerton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Safe Drinking Water Act	Federal Primary Drinking Water Standards – MCLs and MCLGs	42 USC 300f; 40 CFR 141, Subpart O	Establishes drinking water standards for public water systems to protect human health. Includes standards for the following Site chemicals of concern: arsenic, benzene, and benzo(a)pyrene. The National Contingency Plan states that MCLs, not MCLGs, are ARARs for usable aquifers.	ARARs for groundwater that could potentially be used for drinking water, where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections.
Safe Drinking Water Act	Federal Secondary Drinking Water Standards – Secondary MCLs	42 USC 300f; 40 CFR 143	Establishes drinking water standards for public water systems to achieve the aesthetic qualities of drinking water (secondary MCLs).	TBC for groundwater that could potentially be a drinking water source (i.e., achieved as practicable).
Clean Water Act	Federal Ambient Water Quality Criteria	33 USC 1311–1317; 40 CFR 131	Under Clean Water Act, Section 304(a), minimum criteria are developed for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life. The federal recommended water quality criteria are published on EPA's website: http://water.epa.gov/scitech/swguidance/standards/current/index.cfm	ARARs for surface water if more stringent than promulgated state criteria.
Surface Water Quality Standards	State Ambient Water Quality Criteria	Chapter 90.48 RCW; Chapter 173-201A WAC	Establishes water quality standards for protection of human health and for protection of aquatic life (for both acute and chronic exposure durations).	ARARs for surface water where Washington State has adopted, and EPA has approved, water quality standards.
Model Toxics Control Act	State Soil, Air, Groundwater, and Surface Water Cleanup Standards	Chapter 70.105D RCW; Chapter 173-340 WAC	Establishes cleanup levels for Site groundwater, surface water, soil, and air, including rules for evaluating cross-media protectiveness. MTCA cleanup levels cannot be set at concentrations below natural background.	Promulgated numeric cleanup levels are ARARs for soil, air, groundwater, and surface water. Equations to develop cleanup levels are not ARARs.

Table 3-1 – Potential ARARs, Chemical-Specific

Bremerton Gas Works Site
Bremerton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Sediment Management Standards	State Sediment Quality Criteria	Chapters 90.48 & 70.105D RCW; Chapter 173-204 WAC	Establishes both numerical and biological wasting-based standards for the protection of benthic invertebrates in marine sediments. The current rule also defines methods for establishing cleanup levels protective of human health, including protection from risks associated with seafood consumption, analytical considerations, and natural and regional background contamination levels.	SMS cleanup levels will serve as ARARs for the development of sediment cleanup levels.

Notes:
ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
MTCA = Model Toxics Control Act
RCW = Revised Code of Washington
SMS = Sediment Management Standards
TBC = to be considered
USC = United States Code
WAC = Washington Administrative Code

Table 3-2 – Potential ARARs, Location-Specific

Bremerton Gas Works Site
Bremerton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Endangered Species Act	Effects on Endangered Species	16 USC 1531 et seq.; 50 CFR 17	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats, or must take appropriate mitigation steps.	ARAR for remedial actions that may adversely affect endangered or threatened species or critical habitat present at the Site.
Safe Drinking Water Act	Underground Injection Control, Sole Source Aquifer Program, and Wellhead Protection Program	42 USC 300h–300h-8; 40 CFR 300.400(g)(4); Chapter 173-160 WAC; WAC 246-290-135	Resource planning programs designed to prevent contamination of underground sources of drinking water.	The requirements of the City's wellhead protection program are TBCs as a performance standard for groundwater that is a potential drinking water source (i.e., achieved as practicable). (Note that there are no water supply wells near the Site that are currently regulated by the City's program.)
Magnuson-Stevens Fishery Conservation and Management Act	Habitat Impacts	16 USC 1855(b); 50 CFR 600.920	Requires evaluation of impacts on EFH if activities may adversely affect EFH.	ARAR if the remedial action may adversely affect EFH.
Executive Order for Wetlands Protection	Wetlands Impacts	Executive Order 11990 (1977), 40 CFR 6.302(a); 40 CFR 6, App. A	Requires measures to avoid adversely affecting wetlands whenever possible, to minimize wetland destruction, and to preserve the value of wetlands.	ARAR for assessing impacts on wetlands, if any, from the remedial action and for developing appropriate compensatory mitigation.

Notes:
ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
City = City of Bremerton
EFH = essential fish habitat
TBC = to be considered
USC = United States Code
WAC = Washington Administrative Code

Table 3-3 – Potential ARARs, Action-Specific
Bremerton Gas Works Site
Bremerton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Soil Excavation and Upland Filling	Solid Waste Disposal Act	Management and Disposal of Solid Waste	42 USC 6901–6917; 40 CFR 257–258	Establishes requirements for the management and disposal of solid wastes.	ARAR for remedial actions that result in upland disposal of excavated or dredged material.
	Resource Conservation and Recovery Act (RCRA); Washington Hazardous Waste Management Act and Dangerous Waste Regulations	Generation and Management (Transportation, Treatment, Storage, and Disposal) of Hazardous Waste; Off-Site Land Disposal Considerations	42 USC 6921–22; 40 CFR 260, 261, and 268; Chapter 70.105 RCW; Chapter 173-303 WAC (Chapter 173-307 WAC Pollution Prevention Plans is a TBC)	Defines solid wastes subject to regulation as hazardous wastes. Requires management of hazardous waste from "cradle to grave" unless exemption applies. MGP wastes are subject to certain exemptions (e.g., Bevill Amendment provisions)	ARAR for wastes and soils sediments excavated from the Site for off-site disposal, and a TBC for on-site stabilization or containment actions.
	Hazardous Materials Transportation Act	Transport of Hazardous Materials	49 USC 5101 et seq.; 49 CFR 171–177	Establishes requirements for transport of hazardous materials.	ARAR for those hazardous materials (e.g., DNAPL) transported off site.
	Washington Hydraulics Code	Filling of Wetlands	Chapters 75.20 and 77.55 RCW; Chapter 220-110 WAC	Establishes requirements for performing work that would alter existing jurisdictional wetlands.	ARAR if remedial actions such as excavation or capping affect existing jurisdictional wetlands. Remedial actions must result in no net loss of aquatic habitat and function after sequential consideration of avoidance and mitigation, allowing for site-specific evaluations of existing wetland functions.

Table 3-3 – Potential ARARs, Action-Specific

Bremerton Gas Works Site

Bremerton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Soil Excavation and Upland Filling (Continued)	City of Bremerton Shoreline Master Program and Critical Areas Regulations	Shoreline of Statewide Significance; Fish and Wildlife Habitat Conservation Areas	Chapter 90.58 RCW; Chapter 173-14 WAC; City of Bremerton Ordinance #5299 (effective December 4, 2013); Critical Area Regulations (BMC 20.14) are incorporated into the SMP by reference	Establishes replacement requirements for FWHCAs affected by remedial actions to ensure no net loss of existing ecological function; also establishes requirements for buffers and setbacks from shorelines.	ARAR if remedial actions such as excavation or capping result in impacts within 200 feet of ordinary high water mark or designated FWHCAs. Remedial actions must result in no net loss of aquatic habitat and function after sequential consideration of avoidance and mitigation, allowing for site-specific evaluations of existing shoreline habitat and FWHCAs. Washington's vested rights rule governs which SMP requirements apply in a given circumstance. Substantive requirements of the SMP that were in effect when redevelopment project applications were filed may be ARARs for future redevelopment actions at the Site.
Dredging, Capping, and/or Discharge to Puget Sound	Clean Water Act	Federal Ambient Water Quality Criteria	33 USC 1311–1317; 40 CFR 131	Regulates activities that may result in discharges into navigable waters.	ARAR for control of short-term impacts on surface water due to implementation of remedial actions that include dredging, capping, and discharge of treated water into Puget Sound. Incorporates the substantive provisions of relevant and appropriate Joint Aquatic Resources Permit Application (JARPA), Nationwide Permit, and stormwater regulation requirements.

Table 3-3 – Potential ARARs, Action-Specific

Bremerton Gas Works Site
Bremerton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Dredging, Capping, and/or Discharge to Puget Sound (Continued)	Surface Water Quality Standards	State Ambient Water Quality Criteria	Chapter 90.48 RCW; Chapter 173-201A WAC	Regulates activities that may result in discharges into navigable waters.	ARAR for control of short-term impacts on surface water sue to implementation of remedial actions that include dredging, capping, and discharge of treated water into Puget Sound. Incorporates the substantive provisions of relevant and appropriate requirements, where Washington State has adopted, and EPA has approved, water quality standards.
	Clean Water Act	Discharge of Materials into Puget Sound	33 USC 1344; 40 CFR 230	Regulates discharge of dredged and fill material into navigable waters of the United States.	ARAR for dredging and capping activities in Puget Sound.
	Fish and Wildlife Coordination Act	Discharge of Materials, Impoundment or Diversion of Waters in Puget Sound	16 USC 662 and 663; 40 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses, which include discharges of pollutants to water bodies.	ARAR for in-water remedial actions or if treated water is discharged into Puget Sound.
	River and Harbors Act	Placement of Structures in Puget Sound	33 USC 401 et seq.; 33 CFR 320–330	Prohibits the unauthorized obstruction or alteration of any navigable water. Establishes requirements for structures or work in, above, or under navigable waters.	ARAR for remedial actions in Puget Sound.

Table 3-3 – Potential ARARs, Action-Specific

Bremerton Gas Works Site

Bremerton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Dredging, Capping, and/or Discharge to Puget Sound (Continued)	Washington Hydraulics Code	Filling in Puget Sound	Chapter 75.20 and 77.55 RCW; Chapter 220-110 WAC	Establishes requirements for performing work that would use, divert, obstruct, or change the natural flow or bed of Puget Sound.	ARAR for shoreline excavation, dredging, and/or capping actions. Remedial actions must result in no net loss of aquatic habitat or function after sequential consideration of avoidance and mitigation.
Other Remedial Activities	Federal Clean Air Act; Washington Clean Air Act; Puget Sound Air Clean Air Agency Regulations	Air Emission Discharges	42 USC 7401 et seq.; Chapter 70.94 RCW; Chapter 173-400 WAC; PSCAA Regulation III	Regulates air emission discharges.	ARAR for remedial activities that generate fugitive dust or other air emissions, including treatment operations.
	Historic Preservation Act; Washington Historical Activities Act	Alteration of Historic Properties	16 USC 470 et seq.; 36 CFR 800; Chapter 27 RCW	Requires the identification of historic properties potentially affected by remedial actions, and ways to avoid, minimize, or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	ARAR if historic properties are affected by remedial activities. No historic properties have been identified at the Site to date but could potentially be identified during remedial design.
	Archeological and Historic Preservation Act	Alteration of Historic and Archaeological Properties	16 USC 469a-1	Provides for the preservation of historical and archeological data that may be irreparably lost as a result of a federally approved project and mandates only preservation of the data.	ARAR if historical and archeological resources may be irreparably lost by implementation of remedial activities.

Table 3-3 – Potential ARARs, Action-Specific
Bremerton Gas Works Site
Bremerton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Other Remedial Activities (Continued)	Native American Graves Protection and Reparation Act	Alteration of American Graves	25 USC 3001–3013; 43 CFR 10	Requires federal agencies and museums that have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects, and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or state or local government agency that receives federal funds and has possession of, or control over, Native American cultural items.	ARAR if Native American cultural items are present in an excavation or dredging area.

Notes:
ARAR = applicable or relevant and appropriate requirements
BMC = Bremerton Municipal Code
DNAPL = dense non-aqueous phase liquid
EPA = U.S. Environmental Protection Agency
FWHCA = Fish and Wildlife Habitat Conservation Area
MGP = manufactured gas plant
PSCCA = Puget Sound Clean Air Agency
RCW = Revised Code of Washington
SMP = Shoreline Master Program
TBC = to be considered
USC = United States Code
WAC = Washington Administrative Code

Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

		EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
										Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
Analyte	CAS Number	EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015		
Conventionals (mg/kg)											
Cyanide, WAD	57-12-5	--	--	--	--	--	22	140	0.05	22	22
Cyanide, total	57-12-5	1.33	--	--	--	--	--	--	0.05	1.33	
Metals (mg/kg)											
Antimony	7440-36-0	0.142	--	78	0.27	--	31	410	0.0002	0.27	31
Arsenic	7440-38-2	5.7	43	--	46	18	0.61	2.4	0.0002	0.61	0.61
Beryllium	7440-41-7	1.06	--	40	21	--	160	2000	0.0002	21	160
Cadmium	7440-43-9	0.00222	0.77	140	0.36	32	70	800	0.0001	0.36	70
Chromium	7440-47-3	0.4	26	--	34	--	--	--	0.0005	26	--
Cobalt	7440-48-4	0.14	120	--	230	13	23	300	0.0002	13	23
Copper	7440-50-8	5.4	28	80	49	70	3100	41000	0.0005	28	3100
Lead	7439-92-1	0.0537	11	1700	56	120	400	800	0.0001	11	400
Manganese	7439-96-5	--	4300	450	4000	220	1800	23000	0.0005	220	1800
Mercury	7439-97-6	0.1	--	--	--	--	10	43	0.025	10	10
Nickel	7440-02-0	13.6	210	280	130	38	1500	20000	0.0005	38	1500
Selenium	7782-49-2	0.0276	1.2	4.1	0.63	0.52	390	5100	0.002	0.52	390
Silver	7440-22-4	4.04	4.2	--	14	560	390	5100	0.0002	4.2	390
Thallium	7440-28-0	0.0569	--	--	--	--	0.78	10	0.0002	0.78	0.78
Zinc	7440-66-6	6.62	46	120	79	160	23000	310000	0.004	46	23000
Volatile Organic Compounds (VOCs) (ug/kg)											
1,1,1,2-Tetrachloroethane	630-20-6	225000	--	--	--	--	1900	9300	1.00	1900	1900
1,1,1-Trichloroethane	71-55-6	29800	--	--	--	--	8700000	38000000	1.00	8700000	8700000
1,1,2,2-Tetrachloroethane	79-34-5	127	--	--	--	--	560	2800	1.00	560	560
1,1,2-Trichloroethane	79-00-5	28600	--	--	--	--	1100	5300	1.00	1100	1100
1,1,2-Trichlorotrifluoroethane (Freon 113)	76-13-1	--	--	--	--	--	43000000	180000000	2.00	43000000	43000000
1,1-Dichloroethane	75-34-3	20100	--	--	--	--	3300	17000	1.00	3300	3300
1,1-Dichloroethene	75-35-4	8280	--	--	--	--	240000	1100000	1.00	240000	240000
1,2,3-Trichlorobenzene	87-61-6	--	--	--	--	--	49000	490000	5.00	49000	49000
1,2,3-Trichloropropane	96-18-4	3360	--	--	--	--	5	95	2.00	5	5
1,2,4-Trimethylbenzene	95-63-6	--	--	--	--	--	62000	260000	1.00	62000	62000
1,2-Dibromo-3-chloropropane	96-12-8	35.2	--	--	--	--	5.4	69	5.00	5.4	5.4
1,2-Dichloroethane	107-06-2	21200	--	--	--	--	430	2200	1.00	430	430
1,2-Dichloroethene, cis-	156-59-2	--	--	--	--	--	160000	2000000	1.00	160000	160000
1,2-Dichloroethene, trans-	156-60-5	784	--	--	--	--	150000	690000	1.00	150000	150000
1,2-Dichloropropane	78-87-5	32700	--	--	--	--	940	4700	1.00	940	940
1,3,5-Trimethylbenzene (Mesitylene)	108-67-8	--	--	--	--	--	780000	10000000	1.00	780000	780000
1,3-Dichloropropane	142-28-9	--	--	--	--	--	1600000	20000000	1.00	1600000	1600000
1,3-Dichloropropene, cis-	10061-01-5	398	--	--	--	--	--	--	1.00	398	--

Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
		EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015	Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
1,3-Dichloropropene, trans-	10061-02-6	398	--	--	--	--	--	--	1.00	398	--
1,4-Dichloro-2-butene, trans-	110-57-6	--	--	--	--	--	6.9	35	5.00	6.9	6.9
2-Butanone (MEK)	78-93-3	89600	--	--	--	--	28000000	200000000	5.00	28000000	28000000
2-Hexanone (Methyl butyl ketone)	591-78-6	12600	--	--	--	--	210000	1400000	5.00	210000	210000
4-Chlorotoluene	106-43-4	--	--	--	--	--	1600000	20000000	1.00	1600000	1600000
4-Isopropyltoluene (4-Cymene)	99-87-6	--	--	--	--	--	--	--	1.00	--	--
Acetone	67-64-1	2500	--	--	--	--	61000000	630000000	5.00	61000000	61000000
Acrolein	107-02-8	5270	--	--	--	--	150	650	50.0	150	150
Acrylonitrile	107-13-1	23.9	--	--	--	--	240	1200	5.00	240	240
Benzene	71-43-2	255	--	--	--	--	1100	5400	1.00	255	1100
Bromobenzene	108-86-1	--	--	--	--	--	300000	1800000	1.00	300000	300000
Bromochloromethane	74-97-5	--	--	--	--	--	160000	680000	1.00	160000	160000
Bromodichloromethane	75-27-4	540	--	--	--	--	270	1400	1.00	270	270
Bromoform (Tribromomethane)	75-25-2	15900	--	--	--	--	62000	220000	1.00	62000	62000
Bromomethane (Methyl bromide)	74-83-9	235	--	--	--	--	7300	32000	1.00	7300	7300
Carbon disulfide	75-15-0	94.1	--	--	--	--	820000	3700000	1.00	820000	820000
Carbon tetrachloride (Tetrachloromethane)	56-23-5	2980	--	--	--	--	610	3000	1.00	610	610
Chlorobenzene	108-90-7	13100	--	--	--	--	290000	1400000	1.00	290000	290000
Chloroethane	75-00-3	--	--	--	--	--	15000000	61000000	1.00	15000000	15000000
Chloroform	67-66-3	1190	--	--	--	--	290	1500	1.00	290	290
Chloromethane	74-87-3	10400	--	--	--	--	120000	500000	1.00	120000	120000
Dibromochloromethane	124-48-1	2050	--	--	--	--	680	3300	1.00	680	680
Dibromomethane	74-95-3	65000	--	--	--	--	25000	110000	1.00	25000	25000
Dichlorodifluoromethane	75-71-8	39500	--	--	--	--	94000	400000	1.00	94000	94000
Dichloromethane (Methylene chloride)	75-09-2	4050	--	--	--	--	56000	960000	2.00	56000	56000
Ethylbenzene	100-41-4	5160	--	--	--	--	5400	27000	1.00	5400	5400
Ethylene dibromide (1,2-Dibromoethane)	106-93-4	1230	--	--	--	--	34	170	1.00	34	34
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	87-68-3	39.8	--	--	--	--	6200	22000	5.00	6200	6200
Isopropylbenzene (Cumene)	98-82-8	--	--	--	--	--	2100000	11000000	1.00	2100000	2100000
Methyl iodide (Iodomethane)	74-88-4	1230	--	--	--	--	--	--	1.00	1230	--
Methyl isobutyl ketone (4-Methyl-2-pentanone or (MIBK))	108-10-1	443000	--	--	--	--	5300000	53000000	5.00	5300000	5300000
Methyl tert-butyl ether (MTBE)	1634-04-4	--	--	--	--	--	43000	220000	1.00	43000	43000
n-Butylbenzene	104-51-8	--	--	--	--	--	3900000	51000000	1.00	3900000	3900000
n-Propylbenzene	103-65-1	--	--	--	--	--	3400000	21000000	1.00	3400000	3400000
o-Xylene	95-47-6	--	--	--	--	--	690000	3000000	1.00	690000	690000
sec-Butylbenzene	135-98-8	--	--	--	--	--	7800000	100000000	1.00	7800000	7800000
Styrene	100-42-5	4690	--	--	--	--	6300000	36000000	1.00	6300000	6300000
tert-Butylbenzene	98-06-6	--	--	--	--	--	7800000	100000000	1.00	7800000	7800000

Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
		EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015	Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
Tetrachloroethene (PCE)	127-18-4	9920	--	--	--	--	22000	110000	1.00	22000	22000
Toluene	108-88-3	5450	--	--	--	--	5000000	45000000	1.00	5000000	5000000
Total xylene (reported, not calculated)	1330-20-7	10000	--	--	--	--	630000	2700000	2.00	630000	630000
Trichloroethene (TCE)	79-01-6	12400	--	--	--	--	910	6400	1.00	910	910
Trichlorofluoromethane (Fluorotrichloromethane)	75-69-4	16400	--	--	--	--	790000	3400000	1.00	790000	790000
Vinyl acetate	108-05-4	12700	--	--	--	--	970000	4100000	5.00	970000	970000
Vinyl chloride	75-01-4	646	--	--	--	--	60	1700	1.00	60	60
Semivolatile Organic Componds (SVOCs) (ug/kg)											
1,2,4,5-Tetrachlorobenzene	95-94-3	2020	--	--	--	--	18000	180000	67.0	18000	18000
1,2,4-Trichlorobenzene	120-82-1	11100	--	--	--	--	22000	99000	67.0	22000	22000
1,2-Dichlorobenzene	95-50-1	2960	--	--	--	--	1900000	9800000	67.0	1900000	1900000
1,3-Dichlorobenzene	541-73-1	37700	--	--	--	--	--	--	67.0	37700	--
1,4-Dichlorobenzene	106-46-7	546	--	--	--	--	2400	12000	67.0	2400	2400
1,4-Dioxane	123-91-1	2050	--	--	--	--	4900	17000	67.0	4900	4900
2,2'-Oxybis (1-chloropropane)	108-60-1	19900	--	--	--	--	4600	22000	67.0	4600	4600
2,3,4,6-Tetrachlorophenol	58-90-2	199	--	--	--	--	1800000	18000000	67.0	1800000	1800000
2,4,5-Trichlorophenol	95-95-4	14100	--	--	--	--	6100000	62000000	330	6100000	6100000
2,4,6-Trichlorophenol	88-06-2	9940	--	--	--	--	44000	160000	330	44000	44000
2,4-Dichlorophenol	120-83-2	87500	--	--	--	--	180000	1800000	330	180000	180000
2,4-Dimethylphenol	105-67-9	10	--	--	--	--	1200000	12000000	67.0	1200000	1200000
2,4-Dinitrophenol	51-28-5	60.9	--	--	--	--	120000	1200000	670	120000	120000
2,4-Dinitrotoluene	121-14-2	1280	--	--	--	--	1600	5500	330	1600	1600
2,6-Dinitrotoluene	606-20-2	32.8	--	--	--	--	330	1200	330	330	330
2-Chloronaphthalene	91-58-7	12.2	--	--	--	--	6300000	82000000	67.0	6300000	6300000
2-Chlorophenol	95-57-8	243	--	--	--	--	390000	5100000	67.0	390000	390000
2-Methylphenol (o-Cresol)	95-48-7	40400	--	--	--	--	3100000	31000000	67.0	3100000	3100000
2-Nitroaniline	88-74-4	74100	--	--	--	--	610000	6000000	330	610000	610000
2-Nitrophenol	88-75-5	1600	--	--	--	--	--	--	67.0	1600	--
3,3'-Dichlorobenzidine	91-94-1	646	--	--	--	--	1100	3800	330	1100	1100
3-Methylphenol & 4-Methylphenol (m&p-Cresol)	1319-77-3	--	--	--	--	--	6100000	62000000	n/a	6100000	6100000
3-Methylphenol (m-Cresol)	108-39-4	3490	--	--	--	--	3100000	31000000	n/a	3100000	3100000
3-Nitroaniline	99-09-2	3160	--	--	--	--	--	--	330	3160	--
4-Bromophenyl-phenyl ether	101-55-3	--	--	--	--	--	--	--	67.0	--	--
4-Chloro-3-methylphenol	59-50-7	7950	--	--	--	--	6100000	62000000	330	6100000	6100000
4-Chloroaniline	106-47-8	1100	--	--	--	--	2400	8600	330	2400	2400
4-Methylphenol (p-Cresol)	106-44-5	163000	--	--	--	--	6100000	62000000	67.0	6100000	6100000
4-Nitroaniline	100-01-6	21900	--	--	--	--	24000	86000	330	24000	24000
4-Nitrophenol	100-02-7	5120	--	--	--	--	--	--	330	5120	--

Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
		EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015	Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
Aniline	62-53-3	56.8	--	--	--	--	85000	300000	67.0	85000	85000
Benzidine	92-87-5	--	--	--	--	--	0.5	7.5	670	0.5	0.5
Benzoic acid	65-85-0	--	--	--	--	--	240000000	2500000000	670	240000000	240000000
Benzyl alcohol	100-51-6	65800	--	--	--	--	6100000	62000000	330	6100000	6100000
Biphenyl (1,1'-Biphenyl)	92-52-4	--	--	--	--	--	51000	210000	5.0	51000	51000
bis(2-Chloroethoxy)methane	111-91-1	302	--	--	--	--	180000	1800000	67.0	180000	180000
bis(2-Chloroethyl)ether	111-44-4	23700	--	--	--	--	210	1000	67.0	210	210
bis(2-Ethylhexyl)phthalate	117-81-7	925	--	--	--	--	35000	120000	67.0	35000	35000
Butylbenzyl phthalate	85-68-7	239	--	--	--	--	260000	910000	67.0	260000	260000
Dibenzofuran	132-64-9	--	--	--	--	--	78000	1000000	67.0	78000	78000
Diethyl phthalate	84-66-2	24800	--	--	--	--	49000000	490000000	67.0	49000000	49000000
Dimethyl phthalate	131-11-3	734000	--	--	--	--	--	--	67.0	734000	--
Di-n-butyl phthalate	84-74-2	150	--	--	--	--	6100000	62000000	67.0	6100000	6100000
Dinitro-o-cresol (4,6-Dinitro-2-methylphenol)	534-52-1	144	--	--	--	--	4900	49000	670	4900	4900
Di-n-octyl phthalate	117-84-0	709000	--	--	--	--	610000	6200000	67.0	610000	610000
Hexachlorobenzene	118-74-1	199	--	--	--	--	300	1100	67.0	300	300
Hexachlorocyclopentadiene	77-47-4	755	--	--	--	--	370000	3700000	330	370000	370000
Hexachloroethane	67-72-1	596	--	--	--	--	12000	43000	67.0	12000	12000
Isophorone	78-59-1	139000	--	--	--	--	510000	1800000	67.0	510000	510000
Nitrobenzene	98-95-3	1310	--	--	--	--	4800	24000	67.0	4800	4800
n-Nitrosodimethylamine	62-75-9	0.0321	--	--	--	--	2.3	34	330	2.3	2.3
n-Nitrosodi-n-propylamine	621-64-7	544	--	--	--	--	69	250	67.0	69	69
n-Nitrosodiphenylamine	86-30-6	545	--	--	--	--	99000	350000	67.0	99000	99000
Pentachlorophenol	87-86-5	119	2100	31000	2800	5000	890	2700	330	890	890
Phenol	108-95-2	120000	--	--	--	--	18000000	180000000	67.0	18000000	18000000
Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)											
1-Methylnaphthalene	90-12-0	--	--	--	--	--	16000	53000	5.0	16000	16000
2-Methylnaphthalene	91-57-6	3240	--	--	--	--	230000	2200000	5.0	230000	230000
Acenaphthene	83-32-9	682000	--	--	--	--	3400000	33000000	5.0	3400000	3400000
Acenaphthylene	208-96-8	682000	--	--	--	--	--	--	5.0	682000	--
Anthracene	120-12-7	1480000	--	--	--	--	17000000	170000000	5.0	17000000	17000000
Benzo(a)anthracene	56-55-3	5210	--	--	--	--	150	2100	5.0	150	150
Benzo(a)pyrene	50-32-8	1520	--	--	--	--	15	210	5.0	15	15
Benzo(b)fluoranthene	205-99-2	59800	--	--	--	--	150	2100	5.0	150	150
Benzo(g,h,i)perylene	191-24-2	119000	--	--	--	--	--	--	5.0	0	--
Benzo(k)fluoranthene	207-08-9	148000	--	--	--	--	1500	21000	5.0	1500	1500
Chrysene	218-01-9	4730	--	--	--	--	15000	210000	5.0	15000	15000
Dibenzo(a,h)anthracene	53-70-3	18400	--	--	--	--	15	210	5.0	15	15

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Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
		EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015	Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
Fluoranthene	206-44-0	122000	--	--	--	--	2300000	22000000	5.0	2300000	2300000
Fluorene	86-73-7	122000	--	--	--	--	2300000	22000000	5.0	2300000	2300000
Indeno(1,2,3-c,d)pyrene	193-39-5	109000	--	--	--	--	150	2100	5.0	150	150
Naphthalene	91-20-3	99.4	--	--	--	--	3600	18000	5.0	3600	3600
Phenanthrene	85-01-8	45700	--	--	--	--	--	--	5.0	45700	--
Pyrene	129-00-0	78500	--	--	--	--	1700000	17000000	5.0	1700000	1700000
Total HPAH	--	--	--	18000	1100	--	--	--	N/A	1100	--
Total LPAH	--	--	--	29000	100000	--	--	--	N/A	29000	--
Total PAH	--	--	--	--	--	--	--	--	N/A	--	--
Organochlorine Pesticides (ug/kg)											
Hexachlorocyclohexane, alpha-BHC	319-84-6	99.4	--	--	--	--	77	270	1.7	77	77
Hexachlorocyclohexane, beta-BHC	319-85-7	3.98	--	--	--	--	270	960	1.7	270	270
Hexachlorocyclohexane, gamma-BHC (Lindane)	58-89-9	5	--	--	--	--	520	2100	1.7	520	520
Hexachlorocyclohexane, delta-BHC	319-86-8	9940	--	--	--	--	--	--	1.7	9940	--
Heptachlor	76-44-8	5.98	--	--	--	--	110	380	1.7	110	110
Aldrin	309-00-2	3.32	--	--	--	--	29	100	1.7	29	29
Heptachlor epoxide	1024-57-3	152	--	--	--	--	53	190	1.7	53	53
Chlordane	57-74-9	224	--	--	--	--	--	--	1.7	224	--
Chlordane (technical)	12789-03-6	--	--	--	--	--	1600	6500	1.7	1600	1600
Endosulfan-alpha (I)	959-98-8	119	--	--	--	--	--	--	1.7	119	--
4,4'-DDE (p,p'-DDE)	72-55-9	596	--	--	--	--	1400	5100	3.3	1400	1400
Dieldrin	60-57-1	2.38	22	--	4.9	--	30	110	3.3	4.9	30
Endrin	72-20-8	10.1	--	--	--	--	18000	180000	3.3	18000	18000
Endosulfan-beta (II)	33213-65-9	119	--	--	--	--	--	--	3.3	119	--
4,4'-DDD (p,p'-DDD)	72-54-8	758	--	--	--	--	2000	7200	3.3	2000	2000
Endrin aldehyde	7421-93-4	10.5	--	--	--	--	--	--	3.3	10.5	--
4,4'-DDT (p,p'-DDT)	50-29-3	3.5	--	--	--	--	1700	7000	3.3	1700	1700
Endosulfan sulfate	1031-07-8	35.8	--	--	--	--	--	--	3.3	35.8	--
Methoxychlor	72-43-5	19.9	--	--	--	--	310000	3100000	1.7	310000	310000

Table 3-4 - Development of Initial PRGs for Soil

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 5 RCRA Soil Ecological Screening Levels	EPA Ecological Soil Screening Levels - Birds	EPA Ecological Soil Screening Levels - Invertebrates	EPA Ecological Soil Screening Levels - Mammals	EPA Ecological Soil Screening Levels - Plants	EPA Regional Screening Levels (RSLs) - Residential Soil	EPA Regional Screening Levels (RSLs) - Industrial Soil	Laboratory MRL	Initial PRGs used for Data Screening	
		EPA, 2003	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2010	EPA, 2013	EPA, 2013	ARI, 2015	Surface Soil (0-10 feet)	Subsurface Soil (>10 feet)
Polychlorinated Biphenyls (PCBs) (ug/kg)											
Aroclor 1016	12674-11-2	--	--	--	--	--	3900	21000	330	3900	3900
Aroclor 1221	11104-28-2	--	--	--	--	--	140	540	330	140	140
Aroclor 1232	11141-16-5	--	--	--	--	--	140	540	330	140	140
Aroclor 1242	53469-21-9	--	--	--	--	--	220	740	330	220	220
Aroclor 1248	12672-29-6	--	--	--	--	--	220	740	330	220	220
Aroclor 1254	11097-69-1	--	--	--	--	--	220	740	330	220	220
Aroclor 1260	11096-82-5	--	--	--	--	--	220	740	330	220	220
Total PCB Aroclors	--	0.332	--	--	--	--	220	740	330	220	220

Notes:

Compounds frequently associated with MGP-operations.

-- indicates not available
CAS = Chemical Abstract Services
EPA = U.S. Environmental Protection Agency
HPAH = high molecular weight PAH
LPAH = low molecular weight PAH
kg = kilogram
mg = miligram
MGP = manufactured gas plant
ng = nanogram
PRG = preliminary remediation goal
RCRA = Resource Conservation and Recovery Act
RSL = regional screening level
ug = microgram
WAD = Weak Acid Dissociable Cyanide

References:

EPA, 2003. EPA Region 5 Resource Conservation Recovery Act (RCRA) Ecological Screening Levels. August 22, 2003.
EPA, 2010. Ecological Soil Screening Levels. Updated October 20, 2010. Cited: January 15, 2014. Available from: http://www.epa.gov/ecotox/ecossl/.
EPA, 2013. EPA Regional Screening Levels. November 2013. Available from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_run_NOV2013.pdf.

Table 3-5 - Development of Initial PRGs for Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Regional Screening Levels (RSLs) - MCL EPA, 2013	EPA Regional Screening Levels (RSLs) - Tapwater EPA, 2013	Laboratory MRL ARI, 2015	Initial PRGs used for Data Screening
Conventionals (mg/L)					
Cyanide, free	57-12-5	0.2	0.0014	0.00500	0.0014
Metals (ug/L)					
Antimony	7440-36-0	6	6	0.2	6
Arsenic	7440-38-2	10	0.045	0.2	0.045
Beryllium	7440-41-7	4	16	0.2	4
Cadmium	7440-43-9	5	6.9	0.1	5
Chromium	7440-47-3	100	--	0.5	100
Chromium VI	18540-29-9	--	0.031	0.01	0.031
Copper	7440-50-8	1300	620	0.5	620
Lead	7439-92-1	15	15	0.1	15
Mercury	7439-97-6	2	0.63	0.100	0.63
Nickel	7440-02-0	--	300	0.5	300
Selenium	7782-49-2	50	78	0.5	50
Silver	7440-22-4	--	71	0.2	71
Thallium	7440-28-0	2	0.16	0.2	0.16
Zinc	7440-66-6	--	4700	4	4700
Volatile Organic Compounds (VOCs) (ug/L)					
1,1,1,2-Tetrachloroethane	630-20-6	--	0.5	0.200	0.5
1,1,1-Trichloroethane	71-55-6	200	7500	0.200	200
1,1,2,2-Tetrachloroethane	79-34-5	--	0.066	0.200	0.066
1,1,2-Trichloroethane	79-00-5	5	0.24	0.200	0.24
1,1,2-Trichlorotrifluoroethane (Freon 113)	76-13-1	--	53000	0.200	53000
1,1-Dichloroethane	75-34-3	--	2.4	0.200	2.4
1,1-Dichloroethene	75-35-4	7	260	0.200	7
1,2,3-Trichlorobenzene	87-61-6	--	5.2	0.500	5.2
1,2,3-Trichloropropane	96-18-4	--	0.00065	0.500	0.00065
1,2,4-Trimethylbenzene	95-63-6	--	15	0.200	15
1,2-Dibromo-3-chloropropane	96-12-8	0.2	0.00032	0.500	0.00032
1,2-Dichloroethane	107-06-2	5	0.15	0.200	0.15
1,2-Dichloroethene, cis-	156-59-2	70	28	0.200	28
1,2-Dichloroethene, trans-	156-60-5	100	86	0.200	86
1,2-Dichloropropane	78-87-5	5	0.38	0.200	0.38
1,3,5-Trimethylbenzene (Mesitylene)	108-67-8	--	87	0.200	87
1,3-Dichloropropane	142-28-9	--	290	0.200	290
1,3-Dichloropropene, cis-	10061-01-5	--	--	0.200	--
1,3-Dichloropropene, trans-	10061-02-6	--	--	0.200	--
1,4-Dichloro-2-butene, trans-	110-57-6	--	0.0012	1.00	0.0012
2-Butanone (MEK)	78-93-3	--	4900	5.00	4900
2-Chlorotoluene	95-49-8	--	180	0.200	180
2-Hexanone (Methyl butyl ketone)	591-78-6	--	34	5.00	34
4-Chlorotoluene	106-43-4	--	190	0.200	190
4-Isopropyltoluene (4-Cymene)	99-87-6	--	--	0.200	--
Acetone	67-64-1	--	12000	5.00	12000
Acrolein	107-02-8	--	0.041	5.00	0.041
Acrylonitrile	107-13-1	--	0.045	1.00	0.045
Benzene	71-43-2	5	0.39	0.200	0.39
Bromobenzene	108-86-1	--	54	0.200	54
Bromochloromethane	74-97-5	--	83	0.200	83
Bromodichloromethane	75-27-4	80	0.12	0.200	0.12
Bromoform (Tribromomethane)	75-25-2	80	7.9	0.200	7.9
Bromomethane (Methyl bromide)	74-83-9	--	7	1.00	7
Carbon disulfide	75-15-0	--	720	0.200	720
Carbon tetrachloride (Tetrachloromethane)	56-23-5	5	0.39	0.200	0.39
Chlorobenzene	108-90-7	100	72	0.200	72
Chloroethane	75-00-3	--	21000	0.200	21000
Chloroform	67-66-3	80	0.19	0.200	0.19
Chloromethane	74-87-3	--	190	0.500	190
Dibromochloromethane	124-48-1	80	0.15	0.200	0.15
Dibromomethane	74-95-3	--	7.9	0.200	7.9
Dichlorodifluoromethane	75-71-8	--	190	0.200	190
Dichloromethane (Methylene chloride)	75-09-2	5	9.9	1.00	5
Ethylbenzene	100-41-4	700	1.3	0.200	1.3
Ethylene dibromide (1,2-Dibromoethane)	106-93-4	0.05	0.0065	0.200	0.0065
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	87-68-3	--	0.26	0.500	0.26
Isopropylbenzene (Cumene)	98-82-8	--	390	0.200	390
Methyl iodide (Iodomethane)	74-88-4	--	--	1.00	--

Table 3-5 - Development of Initial PRGs for Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Regional Screening Levels (RSLs) - MCL EPA, 2013	EPA Regional Screening Levels (RSLs) - Tapwater EPA, 2013	Laboratory MRL ARI, 2015	Initial PRGs used for Data Screening
Methyl isobutyl ketone (4-Methyl-2-pentanone or (MIBK))	108-10-1	--	1000	5.00	1000
Methyl tert-butyl ether (MTBE)	1634-04-4	--	12	0.500	12
n-Butylbenzene	104-51-8	--	780	0.200	780
n-Propylbenzene	103-65-1	--	530	0.200	530
o-Xylene	95-47-6	--	190	0.200	190
sec-Butylbenzene	135-98-8	--	1600	0.200	1600
Styrene	100-42-5	100	1100	0.200	100
tert-Butylbenzene	98-06-6	--	510	0.200	510
Tetrachloroethene (PCE)	127-18-4	5	9.7	0.200	5
Toluene	108-88-3	1000	860	0.200	860
Total Xylene	--	--	--	n/a	--
Trichloroethene (TCE)	79-01-6	5	0.44	0.200	0.44
Trichlorofluoromethane (Fluorotrichloromethane)	75-69-4	--	1100	0.200	1100
Vinyl acetate	108-05-4	--	410	0.200	410
Vinyl chloride	75-01-4	2	0.015	0.200	0.015
Semivolatile Organic Compounds (SVOCs) (ug/L)					
1,2,4-Trichlorobenzene	120-82-1	70	0.99	0.254	0.99
1,2-Dichlorobenzene	95-50-1	600	280	0.250	280
1,3-Dichlorobenzene	541-73-1	--	--	0.266	--
1,4-Dichlorobenzene	106-46-7	75	0.42	0267	0.42
1,4-Dioxane	123-91-1	--	0.67	0.4	0.67
2,2'-Oxybis (1-chloropropane)	108-60-1	--	0.31	0.241	0.31
2,3,4,6-Tetrachlorophenol	58-90-2	--	170	0.244	170
2,4,5-Trichlorophenol	95-95-4	--	890	1.10	890
2,4,6-Trichlorophenol	88-06-2	--	3.5	1.04	3.5
2,4-Dichlorophenol	120-83-2	--	35	1.11	35
2,4-Dimethylphenol	105-67-9	--	270	1.12	270
2,4-Dinitrophenol	51-28-5	--	30	3.35	30
2,4-Dinitrotoluene	121-14-2	--	0.2	1.12	0.2
2,6-Dinitrotoluene	606-20-2	--	0.042	1.14	0.042
2-Chloronaphthalene	91-58-7	--	550	0.248	550
2-Chlorophenol	95-57-8	--	71	0.220	71
2-Methylphenol (o-Cresol)	95-48-7	--	720	0.211	720
2-Nitroaniline	88-74-4	--	150	1.46	150
2-Nitrophenol	88-75-5	--	--	0.263	--
3,3'-Dichlorobenzidine	91-94-1	--	0.11	1.77	0.11
3-Methylphenol & 4-Methylphenol (m&p-Cresol)	1319-77-3	--	1400	n/a	1400
3-Methylphenol (m-Cresol)	108-39-4	--	720	n/a	720
3-Nitroaniline	99-09-2	--	--	1.53	--
4-Bromophenyl-phenyl ether	101-55-3	--	--	0.238	--
4-Chloro-3-methylphenol	59-50-7	--	1100	1.12	1100
4-Chloroaniline	106-47-8	--	0.32	1.73	0.32
4-Methylphenol (p-Cresol)	106-44-5	--	1400	0.468	1400
4-Nitroaniline	100-01-6	--	3.3	2.02	3.3
4-Nitrophenol	100-02-7	--	--	1.75	--
Aniline	62-53-3	--	12	0.973	12
Benzoic acid	65-85-0	--	58000	3.92	58000
Benzyl alcohol	100-51-6	--	1500	0.552	1500
bis(2-Chloroethoxy)methane	111-91-1	--	46	0.237	46
bis(2-Chloroethyl)ether	111-44-4	--	0.012	0.248	0.012
bis(2-Ethylhexyl)phthalate	117-81-7	6	4.8	2.14	4.8
Butylbenzyl phthalate	85-68-7	--	14	0.299	14
Dibenzofuran	132-64-9	--	5.8	0.309	5.8
Diethyl phthalate	84-66-2	--	11000	0.273	11000
Dimethyl phthalate	131-11-3	--	--	0.259	--
Di-n-butyl phthalate	84-74-2	--	670	0.291	670
Dinitro-o-cresol (4,6-Dinitro-2-methylphenol)	534-52-1	--	1.2	3.61	1.2
Di-n-octyl phthalate	117-84-0	--	160	0.268	160
Hexachlorobenzene	118-74-1	1	0.042	0.280	0.042
Hexachlorocyclopentadiene	77-47-4	50	22	1.08	22
Hexachloroethane	67-72-1	--	0.79	0.300	0.79
Isophorone	78-59-1	--	67	0.423	67
Nitrobenzene	98-95-3	--	0.12	0.253	0.12
n-Nitrosodimethylamine	62-75-9	--	0.00042	1.33	0.00042
n-Nitrosodi-n-propylamine	621-64-7	--	0.0093	0.269	0.0093
n-Nitrosodiphenylamine	86-30-6	--	10	0.299	10

Table 3-5 - Development of Initial PRGs for Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Regional Screening Levels (RSLs) - MCL EPA, 2013	EPA Regional Screening Levels (RSLs) - Tapwater EPA, 2013	Laboratory MRL ARI, 2015	Initial PRGs used for Data Screening
Pentachlorophenol	87-86-5	1	0.035	1.89	0.035
Phenol	108-95-2	--	4500	0.271	4500
Polycyclic Aromatic Hydrocarbons (PAHs)(ug/L)					
1-Methylnaphthalene	90-12-0	--	0.97	0.0100	0.97
2-Methylnaphthalene	91-57-6	--	27	0.0100	27
Acenaphthene	83-32-9	--	400	0.0100	400
Acenaphthylene	208-96-8	--	--	0.0100	--
Anthracene	120-12-7	--	1300	0.0100	1300
Benzo(a)anthracene	56-55-3	--	0.029	0.0100	0.029
Benzo(a)pyrene	50-32-8	0.2	0.0029	0.0100	0.0029
Benzo(b)fluoranthene	205-99-2	--	0.029	0.0100	0.029
Benzo(g,h,i)perylene	191-24-2	--	--	0.0100	--
Benzo(k)fluoranthene	207-08-9	--	0.29	0.0100	0.29
Chrysene	218-01-9	--	2.9	0.0100	2.9
Dibenzo(a,h)anthracene	53-70-3	--	0.0029	0.0100	0.0029
Fluoranthene	206-44-0	--	630	0.0100	630
Fluorene	86-73-7	--	220	0.0100	220
Indeno(1,2,3-c,d)pyrene	193-39-5	--	0.029	0.0100	0.029
Naphthalene	91-20-3	--	0.14	0.0100	0.14
Phenanthrene	85-01-8	--	--	0.0100	--
Pyrene	129-00-0	--	87	0.0100	87
Total Benzofluoranthenes (b,j,k)	--	--	--	#N/A	--
Total HPAH	--	--	--	#N/A	--
Total LPAH	--	--	--	#N/A	--
Total PAH	--	--	--	#N/A	--
Polychlorinated Biphenyls (PCBs) (ug/L)					
Aroclor 1016	12674-11-2	--	0.96	1.0	0.96
Aroclor 1221	11104-28-2	--	0.004	1.0	0.004
Aroclor 1232	11141-16-5	--	0.004	1.0	0.004
Aroclor 1242	53469-21-9	--	0.034	1.0	0.034
Aroclor 1248	12672-29-6	--	0.034	1.0	0.034
Aroclor 1254	11097-69-1	--	0.034	1.0	0.034
Aroclor 1260	11096-82-5	--	0.034	1.0	0.034
Total PCB Aroclors	--	--	0.17		0.17

Notes:

Compounds frequently associated with MGP-operations.

'-- indicates not available

CAS = Chemical Abstract Services

EPA = U. S. Environmental Protection Agency

L = liter

MCL = maximum contaminant level

mg = miligram

MGP = manufactured gas plant

ng = nanogram

PRG = preliminary remediation goal

RSL = regional screening level

ug = microgram

References:

EPA, 2013. EPA Regional Screening Levels. November 2013. Available from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_run_NOV2013.pdf.

Table 3-6 - Development of Initial PRGs for Sediment

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	SMS Marine Sediment Cleanup Objective (SCO[1]/LAET[2]) DOE, 2013	SMS Marine Cleanup Screening Level (CSL[1]/2LAET[2]) DOE, 2013	EPA Region 5 RCRA Sediment Ecological Screening Levels EPA, 2003	EPA Region 3 BTAG Marine Sediment Screening Benchmarks EPA, 2006	Effects Range-Low (ERL) Long et al., 1995	Effects Range-Median (ERM) Long et al., 1995	Initial PRGs used for Data Screening
Alkane Isomers (ug/kg)								
n-Hexane (C6)	110-54-3	--	--	--	39.60	--	--	39.6
Conventionals (mg/kg)								
Cyanide, WAD	57-12-5	--	--	--	0.1	--	--	0.1
Cyanide, total	57-12-5	--	--	0.0001	--	--	--	0.0001
Sulfide	18496-25-8	--	--	--	130	--	--	130
Metals (mg/kg)								
Antimony	7440-36-0	--	--	--	2	--	--	2
Arsenic	7440-38-2	57	93	9.79	7.24	8.2	70	57
Beryllium	7440-41-7	--	--	--	--	--	--	--
Cadmium	7440-43-9	5.1	6.7	0.99	0.68	1.2	9.6	5.1
Chromium	7440-47-3	260	270	43.4	52.3	81	370	260
Chromium III	16065-83-1	--	--	--	--	--	--	--
Chromium VI	18540-29-9	--	--	--	--	--	--	--
Copper	7440-50-8	390	390	31.6	18.7	34	270	390
Lead	7439-92-1	450	530	35.8	30.2	46.7	218	450
Mercury	7439-97-6	0.41	0.59	0.174	0.13	0.15	0.71	0.41
Nickel	7440-02-0	--	--	22.7	15.9	20.9	51.6	20.9
Selenium	7782-49-2	--	--	--	2	--	--	2
Silver	7440-22-4	6.1	6.1	0.5	0.73	1	3.7	6.1
Thallium	7440-28-0	--	--	--	--	--	--	--
Zinc	7440-66-6	410	960	121	124	150	410	410
Metals, Organic (ug/kg)								
Tributyltin	688-73-3	--	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)								
1-Methylnaphthalene	90-12-0	--	--	--	--	--	--	--
2-Methylnaphthalene	91-57-6	670	670	20.2	20.2	70	670	670
Acenaphthene	83-32-9	500	500	6.71	6.71	16	500	500
Acenaphthylene	208-96-8	1300	1300	5.87	5.87	44	640	1300
Anthracene	120-12-7	960	960	57.2	46.9	85.3	1100	960
Benzo(a)anthracene	56-55-3	1300	1600	108	74.8	261	1600	1300
Benzo(a)pyrene	50-32-8	1600	1600	150	88.8	430	1600	1600
Benzo(b)fluoranthene	205-99-2	--	--	10400	--	--	--	10400
Benzo(b,k)fluoranthene	--	--	--	--	27.2	--	--	27.2
Benzo(g,h,i)perylene	191-24-2	670	720	170	170	--	--	670
Benzo(j)fluoranthene	205-82-3	--	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	--	--	240	240	--	--	240
Chrysene	218-01-9	1400	2800	166	108	384	2800	1400
Dibenzo(a,h)anthracene	53-70-3	230	230	33	6.22	63.4	260	230
Fluoranthene	206-44-0	1700	2500	423	113	600	5100	1700
Fluorene	86-73-7	540	540	77.4	21.2	19	540	540
Indeno(1,2,3-c,d)pyrene	193-39-5	600	690	200	17	--	--	600
Naphthalene	91-20-3	2100	2100	176	34.6	160	2100	2100
Phenanthrene	85-01-8	1500	1500	204	86.7	240	1500	1500
Pyrene	129-00-0	2600	3300	195	153	665	2600	2600
Total Benzofluoranthenes (b,j,k)	--	3200	3600	--	--	--	--	3200
Total HPAH	--	12000	17000	--	655	1700	9600	12000
Total LPAH	--	5200	5200	--	312	552	3160	5200
Total PAH	--	--	--	--	2900	4022	44792	4022
Polycyclic Aromatic Hydrocarbons (PAHs) (mg/kg-OC)								
2-Methylnaphthalene	91-57-6	38	64	--	--	--	--	38
Acenaphthene	83-32-9	16	57	--	--	--	--	16
Acenaphthylene	208-96-8	66	66	--	--	--	--	66
Anthracene	120-12-7	220	1200	--	--	--	--	220
Benzo(a)anthracene	56-55-3	110	270	--	--	--	--	110
Benzo(a)pyrene	50-32-8	99	210	--	--	--	--	99
Benzo(g,h,i)perylene	191-24-2	31	78	--	--	--	--	31
Chrysene	218-01-9	110	460	--	--	--	--	110
Dibenzo(a,h)anthracene	53-70-3	12	33	--	--	--	--	12
Fluoranthene	206-44-0	160	1200	--	--	--	--	160
Fluorene	86-73-7	23	79	--	--	--	--	23
Indeno(1,2,3-c,d)pyrene	193-39-5	34	88	--	--	--	--	34
Naphthalene	91-20-3	99	170	--	--	--	--	99
Phenanthrene	85-01-8	100	480	--	--	--	--	100
Pyrene	129-00-0	1000	1400	--	--	--	--	1000
Total Benzofluoranthenes (b,j,k)	--	230	450	--	--	--	--	230
Total HPAH	--	960	5300	--	--	--	--	960
Total LPAH	--	370	780	--	--	--	--	370
Polychlorinated Biphenyls (PCBs) (ug/kg)								
Aroclor 1016	12674-11-2	--	--	--	--	--	--	--
Aroclor 1221	11104-28-2	--	--	--	--	--	--	--
Aroclor 1232	11141-16-5	--	--	--	--	--	--	--
Aroclor 1242	53469-21-9	--	--	--	--	--	--	--
Aroclor 1248	12672-29-6	--	--	--	--	--	--	--
Aroclor 1254	11097-69-1	--	--	--	63.3	--	--	63.3
Aroclor 1260	11096-82-5	--	--	--	--	--	--	--
Aroclor 1262	37324-23-5	--	--	--	--	--	--	--
Aroclor 1268	11100-14-4	--	--	--	--	--	--	--
Total PCB Aroclors	--	130	1000	59.8	40	22.7	180	130
Polychlorinated Biphenyls (PCBs) (mg/kg-OC)								
Total PCB Aroclors	--	12	65	--	--	--	--	12
Semivolatile Organic Compounds (SVOCs)(ug/kg)								
1,2,4,5-Tetrachlorobenzene	95-94-3	--	--	1252	47000	--	--	47000
1,2,4-Trichlorobenzene	120-82-1	31	51	5062	473	--	--	31
1,2-Dichlorobenzene	95-50-1	35	50	294	989	--	--	35
1,3-Dichlorobenzene	541-73-1	--	--	1315	842	--	--	842
1,4-Dichlorobenzene	106-46-7	110	110	318	460	--	--	110
2,2'-Oxybis (1-chloropropane)	108-60-1	--	--	--	--	--	--	--
2,3,4,6-Tetrachlorophenol	58-90-2	--	--	129	284	--	--	284
2,4,5-Trichlorophenol	95-95-4	--	--	--	819	--	--	819
2,4,6-Trichlorophenol	88-06-2	--	--	208	2650	--	--	2650

Table 3-6 - Development of Initial PRGs for Sediment

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	SMS Marine Sediment Cleanup Objective (SCO[1]/LAET[2]) DOE, 2013	SMS Marine Cleanup Screening Level (CSL[1]/2LAET[2]) DOE, 2013	EPA Region 5 RCRA Sediment Ecological Screening Levels EPA, 2003	EPA Region 3 BTAG Marine Sediment Screening Benchmarks EPA, 2006	Effects Range-Low (ERL) Long et al., 1995	Effects Range-Median (ERM) Long et al., 1995	Initial PRGs used for Data Screening
2,4-Dichlorophenol	120-83-2	--	--	81.7	117	--	--	117
2,4-Dimethylphenol	105-67-9	29	29	304	29	--	--	29
2,4-Dinitrophenol	51-28-5	--	--	6.21	--	--	--	6.21
2,4-Dinitrotoluene	121-14-2	--	--	14.4	41.6	--	--	41.6
2,6-Dinitrotoluene	606-20-2	--	--	39.8	--	--	--	39.8
2-Chloronaphthalene	91-58-7	--	--	417	--	--	--	417
2-Chlorophenol	95-57-8	--	--	31.9	344	--	--	344
2-Methylphenol (o-Cresol)	95-48-7	63	63	55.4	--	--	--	63
2-Nitroaniline	88-74-4	--	--	--	--	--	--	--
2-Nitrophenol	88-75-5	--	--	--	--	--	--	--
3,3'-Dichlorobenzidine	91-94-1	--	--	127	2060	--	--	2060
3-Methylphenol & 4-Methylphenol (m&p-Cresol)	1319-77-3	--	--	--	--	--	--	--
3-Methylphenol (m-Cresol)	108-39-4	--	--	52.4	--	--	--	52.4
3-Nitroaniline	99-09-2	--	--	--	--	--	--	--
4-Bromophenyl-phenyl ether	101-55-3	--	--	1550	1230	--	--	1230
4-Chloro-3-methylphenol	59-50-7	--	--	388	--	--	--	388
4-Chloroaniline	106-47-8	--	--	146	--	--	--	146
4-Methylphenol (p-Cresol)	106-44-5	670	670	20.2	670	--	--	670
4-Nitroaniline	100-01-6	--	--	--	--	--	--	--
4-Nitrophenol	100-02-7	--	--	13.3	--	--	--	13.3
Acetophenone	98-86-2	--	--	--	--	--	--	--
Aniline	62-53-3	--	--	0.31	--	--	--	0.31
Atrazine	1912-24-9	--	--	--	6.62	--	--	6.62
Benzaldehyde	100-52-7	--	--	--	--	--	--	--
Benzidine	92-87-5	--	--	--	--	--	--	--
Benzoic acid	65-85-0	650	650	--	650	--	--	650
Benzyl alcohol	100-51-6	57	73	1.04	--	--	--	57
Biphenyl (1,1'-Biphenyl)	92-52-4	--	--	--	1220	--	--	1220
bis(2-Chloroethoxy)methane	111-91-1	--	--	--	--	--	--	--
bis(2-Chloroethyl)ether	111-44-4	--	--	3520	--	--	--	3520
bis(2-Ethylhexyl)phthalate	117-81-7	1300	3100	182	182	--	--	1300
Butylbenzyl phthalate	85-68-7	63	900	1970	16800	--	--	63
Caprolactam	105-60-2	--	--	--	--	--	--	--
Dibenzofuran	132-64-9	540	540	449	7300	--	--	540
Diethyl phthalate	84-66-2	200	1200	295	218	--	--	200
Dimethyl phthalate	131-11-3	71	160	--	--	--	--	71
Di-n-butyl phthalate	84-74-2	1400	5100	1114	1160	--	--	1400
Dinitro-o-cresol (4,6-Dinitro-2-methylphenol)	534-52-1	--	--	104	--	--	--	104
Di-n-octyl phthalate	117-84-0	6200	6200	40600	--	--	--	6200
Hexachlorobenzene	118-74-1	22	70	20	20	--	--	22
Hexachlorocyclopentadiene	77-47-4	--	--	901	139	--	--	139
Hexachloroethane	67-72-1	--	--	584	804	--	--	804
Isophorone	78-59-1	--	--	432	--	--	--	432
Nitrobenzene	98-95-3	--	--	145	--	--	--	145
n-Nitrosodimethylamine	62-75-9	--	--	--	--	--	--	--
n-Nitrosodi-n-propylamine	621-64-7	--	--	--	--	--	--	--
n-Nitrosodiphenylamine	86-30-6	28	40	--	422000	--	--	28
Pentachlorophenol	87-86-5	360	690	23000	7970	--	--	360
Phenol	108-95-2	420	1200	49.1	420	--	--	420
Semivolatile Organic Compounds (SVOCs) (mg/kg-OC)								
1,2,4-Trichlorobenzene	120-82-1	0.81	1.8	--	--	--	--	0.81
1,2-Dichlorobenzene	95-50-1	2.3	2.3	--	--	--	--	2.3
1,4-Dichlorobenzene	106-46-7	3.1	9	--	--	--	--	3.1
bis(2-Ethylhexyl)phthalate	117-81-7	47	78	--	--	--	--	47
Butylbenzyl phthalate	85-68-7	4.9	64	--	--	--	--	4.9
Dibenzofuran	132-64-9	15	58	--	--	--	--	15
Diethyl phthalate	84-66-2	61	110	--	--	--	--	61
Dimethyl phthalate	131-11-3	53	53	--	--	--	--	53
Di-n-butyl phthalate	84-74-2	220	1700	--	--	--	--	220
Di-n-octyl phthalate	117-84-0	58	4500	--	--	--	--	58
Hexachlorobenzene	118-74-1	0.38	2.3	--	--	--	--	0.38
n-Nitrosodiphenylamine	86-30-6	11	11	--	--	--	--	11
Volatile Organic Compounds (VOCs) (ug/kg)								
1,1,1,2-Tetrachloroethane	630-20-6	--	--	--	--	--	--	--
1,1,1-Trichloroethane	71-55-6	--	--	213	856	--	--	856
1,1,2,2-Tetrachloroethane	79-34-5	--	--	850	202	--	--	202
1,1,2-Trichloroethane	79-00-5	--	--	518	570	--	--	570
1,1,2-Trichlorotrifluoroethane (Freon 113)	76-13-1	--	--	--	--	--	--	--
1,1-Dichloroethane	75-34-3	--	--	0.575	--	--	--	0.575
1,1-Dichloroethene	75-35-4	--	--	19.4	2780	--	--	2780
1,2,3-Trichlorobenzene	87-61-6	--	--	--	858	--	--	858
1,2,3-Trichloropropane	96-18-4	--	--	--	--	--	--	--
1,2,4-Trimethylbenzene	95-63-6	--	--	--	--	--	--	--
1,2-Dibromo-3-chloropropane	96-12-8	--	--	--	--	--	--	--
1,2-Dichloroethane	107-06-2	--	--	260	--	--	--	260
1,2-Dichloroethene, cis-	156-59-2	--	--	--	--	--	--	--
1,2-Dichloroethene, trans-	156-60-5	--	--	654	1050	--	--	1050
1,2-Dichloropropane	78-87-5	--	--	333	--	--	--	333
1,3,5-Trimethylbenzene (Mesitylene)	108-67-8	--	--	--	--	--	--	--
1,3-Dichloropropane	142-28-9	--	--	--	--	--	--	--
1,3-Dichloropropene, cis-	10061-01-5	--	--	--	--	--	--	--
1,3-Dichloropropene, trans-	10061-02-6	--	--	--	--	--	--	--
1,4-Dichloro-2-butene, trans-	110-57-6	--	--	--	--	--	--	--
1,4-Dioxane	123-91-1	--	--	119	--	--	--	119
2-Butanone (MEK)	78-93-3	--	--	42.4	--	--	--	42.4
2-Chlorotoluene	95-49-8	--	--	--	--	--	--	--
2-Hexanone (Methyl butyl ketone)	591-78-6	--	--	58.2	--	--	--	58.2
4-Chlorotoluene	106-43-4	--	--	--	--	--	--	--
4-Isopropyltoluene (4-Cymene)	99-87-6	--	--	--	--	--	--	--
Acetone	67-64-1	--	--	9.9	--	--	--	9.9
Acrolein	107-02-8	--	--	0.00152	--	--	--	0.00152
Acrylonitrile	107-13-1	--	--	1.2	--	--	--	1.2

Table 3-6 - Development of Initial PRGs for Sediment

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	SMS Marine Sediment Cleanup Objective (SCO[1]/LAET[2]) DOE, 2013	SMS Marine Cleanup Screening Level (CSL[1]/2LAET[2]) DOE, 2013	EPA Region 5 RCRA Sediment Ecological Screening Levels EPA, 2003	EPA Region 3 BTAG Marine Sediment Screening Benchmarks EPA, 2006	Effects Range-Low (ERL) Long et al., 1995	Effects Range-Median (ERM) Long et al., 1995	Initial PRGs used for Data Screening
Benzene	71-43-2	--	--	142	137	--	--	137
Bromobenzene	108-86-1	--	--	--	--	--	--	--
Bromochloromethane	74-97-5	--	--	--	--	--	--	--
Bromodichloromethane	75-27-4	--	--	--	--	--	--	--
Bromoform (Tribromomethane)	75-25-2	--	--	492	1310	--	--	1310
Bromomethane (Methyl bromide)	74-83-9	--	--	1.37	--	--	--	1.37
Carbon disulfide	75-15-0	--	--	23.9	0.851	--	--	0.851
Carbon tetrachloride (Tetrachloromethane)	56-23-5	--	--	1450	7240	--	--	7240
Chlorobenzene	108-90-7	--	--	291	162	--	--	162
Chloroethane	75-00-3	--	--	--	--	--	--	--
Chloroform	67-66-3	--	--	121	--	--	--	121
Chloromethane	74-87-3	--	--	--	--	--	--	--
Cyclohexane	110-82-7	--	--	--	--	--	--	--
Dibromochloromethane	124-48-1	--	--	--	--	--	--	--
Dibromomethane	74-95-3	--	--	--	--	--	--	--
Dichlorodifluoromethane	75-71-8	--	--	--	--	--	--	--
Dichloromethane (Methylene chloride)	75-09-2	--	--	159	--	--	--	159
Ethylbenzene	100-41-4	--	--	175	305	--	--	305
Ethylene dibromide (1,2-Dibromoethane)	106-93-4	--	--	--	--	--	--	--
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	87-68-3	11	120	26.5	--	--	--	11
Isopropylbenzene (Cumene)	98-82-8	--	--	--	86	--	--	86
Methyl acetate	79-20-9	--	--	--	--	--	--	--
Methyl iodide (Iodomethane)	74-88-4	--	--	--	--	--	--	--
Methyl isobutyl ketone (4-Methyl-2-pentanone or (MIBK))	108-10-1	--	--	25.1	--	--	--	25.1
Methyl tert-butyl ether (MTBE)	1634-04-4	--	--	--	--	--	--	--
n-Butylbenzene	104-51-8	--	--	--	--	--	--	--
n-Propylbenzene	103-65-1	--	--	--	--	--	--	--
o-Xylene	95-47-6	--	--	--	--	--	--	--
sec-Butylbenzene	135-98-8	--	--	--	--	--	--	--
Styrene	100-42-5	--	--	254	7070	--	--	7070
tert-Butylbenzene	98-06-6	--	--	--	--	--	--	--
Tetrachloroethene (PCE)	127-18-4	--	--	990	190	--	--	190
Toluene	108-88-3	--	--	1220	1090	--	--	1090
Total xylene (reported, not calculated)	1330-20-7	--	--	433	--	--	--	433
Total Xylene	--	--	--	433	--	--	--	433
Trichloroethene (TCE)	79-01-6	--	--	112	8950	--	--	8950
Trichlorofluoromethane (Fluorotrichloromethane)	75-69-4	--	--	--	--	--	--	--
Vinyl acetate	108-05-4	--	--	13	--	--	--	13
Vinyl chloride	75-01-4	--	--	202	--	--	--	202
Volatile Organic Compounds (VOCs) (mg/kg-OC)								
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	87-68-3	3.9	6.2	--	--	--	--	3.9

Notes:

Compounds frequently associated with MGP-operations

'-- indicates not available

1 = This criteria will be used when total organic carbon (TOC) is between 0.5% to 5%.

2 = This criteria will be used when total organic carbon (TOC) is less than 0.5% or greater than 5%.

2LAET = Second Lowest Apparent Effects Threshold

BTAG = Biological Technical Assistance Group

CAS = Chemical Abstract Services

CSL = Cleanup Screening Level

DOE = Washington Department of Ecology

EPA = United States Environmental Protection Agency

kg = kilogram

LAET = Lowest Apparent Effects Threshold

mg = miligram

MGP = Manufactured Gas Plant

ng = nanogram

OC = organic carbon

PRG = preliminary remediation goal

RCRA = Resource Conservation and Recovery Act

SCO = Sediment Cleanup Objective

SMS = Sediment Management Standards

ug = microgram

References:

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Long, E.R, D. MacDonald, S. Smith, and F. Calder, 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 1991:81-97.

Table 3-7 - Development of Initial PRGs for Surface Water

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 3 BTAG Marine Water Screening Benchmarks EPA, 2006	National Recommended Water Quality Criteria - Aquatic Life Criteria - Saltwater CCC (chronic)[1] EPA, 2013	National Recommended Water Quality Criteria - Aquatic Life Criteria - Saltwater CMC (acute)[1] EPA, 2013	EPA Region 5 RCRA - Ecological Screening Levels - Water EPA, 2003	National Recommended Water Quality Criteria - Human Health for the Consumption of Organisms EPA, 2013	Initial PRGs used for Data Screening
Alkane Isomers (ug/L)							
n-Hexane (C6)	110-54-3	0.58	--	--	--	--	0.58
Conventionals (mg/L)							
Cyanide, free	57-12-5	0.001	0.001	0.001	--	--	0.001
Cyanide, total	57-12-5	--	--	--	0.0052	0.14	0.14
Sulfide	18496-25-8	--	--	--	--	--	--
Metals (ug/L)							
Antimony	7440-36-0	500	--	--	80	640	640
Arsenic	7440-38-2	12.5 (a)	36	69	148	0.14	0.14
Beryllium	7440-41-7	0.66	--	--	3.6	--	0.66
Cadmium	7440-43-9	0.12 (a)	8.8	40	0.15	--	8.8
Chromium	7440-47-3	57.5	--	--	42	--	57.5
Chromium III	16065-83-1	56 (a)	--	--	--	--	56
Chromium VI	18540-29-9	1.5 (a)	50	1100	--	--	50
Copper	7440-50-8	3.1	3.1	4.8	1.58	--	3.1
Lead	7439-92-1	8.1	8.1	210	1.17	--	8.1
Mercury	7439-97-6	0.016 (a)	0.94	1.8	0.0013	--	0.94
Nickel	7440-02-0	8.2	8.2	74	28.9	4600	8.2
Selenium	7782-49-2	71	71	290	5	4200	71
Silver	7440-22-4	0.23	--	1.9	0.12	--	0.23
Thallium	7440-28-0	21.3	--	--	10	0.47	0.47
Zinc	7440-66-6	81	81	90	65.7	26000	81
Metals, Organic (ug/L)							
Tributyltin	688-73-3	0.001 (a)	0.0074	0.42	--	--	0.0074
Polycyclic Aromatic Hydrocarbons (PAHs) (ug/L)							
1-Methylnaphthalene	90-12-0	2.1	--	--	--	--	2.1
2-Methylnaphthalene	91-57-6	4.2	--	--	330	--	4.2
Acenaphthene	83-32-9	6.6	--	--	38	990	990
Acenaphthylene	208-96-8	--	--	--	4840	--	4840
Anthracene	120-12-7	0.18	--	--	0.035	40000	40000
Benzo(a)anthracene	56-55-3	0.018	--	--	0.025	0.018	0.018
Benzo(a)pyrene	50-32-8	0.015	--	--	0.014	0.018	0.018
Benzo(b)fluoranthene	205-99-2	--	--	--	9.07	0.018	0.018
Benzo(b,k)fluoranthene	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	191-24-2	--	--	--	7.64	--	7.64
Benzo(j)fluoranthene	205-82-3	--	--	--	--	--	--
Benzo(k)fluoranthene	207-08-9	--	--	--	--	0.018	0.018
Chrysene	218-01-9	--	--	--	--	0.018	0.018
Dibenzo(a,h)anthracene	53-70-3	--	--	--	--	0.018	0.018
Fluoranthene	206-44-0	1.6	--	--	1.9	140	140
Fluorene	86-73-7	2.5	--	--	19	5300	5300
Indeno(1,2,3-c,d)pyrene	193-39-5	--	--	--	4.31	0.018	0.018
Naphthalene	91-20-3	1.4 (a)	--	--	13	--	13
Phenanthrene	85-01-8	1.5	--	--	3.6	--	1.5
Pyrene	129-00-0	0.24	--	--	0.3	4000	4000
Total Benzofluoranthenes (b,j,k)	--	--	--	--	--	--	--
Total HPAH	--	--	--	--	--	--	--
Total LPAH	--	--	--	--	--	--	--
Total PAH	--	--	--	--	--	--	--
Polychlorinated Biphenyls (PCBs) (ug/L)							
	12674-11-2	--	--	--	--	--	--
Aroclor 1221	11104-28-2	--	--	--	--	--	--
Aroclor 1232	11141-16-5	--	--	--	--	--	--
Aroclor 1242	53469-21-9	--	--	--	--	--	--
Aroclor 1248	12672-29-6	--	--	--	--	--	--
Aroclor 1254	11097-69-1	--	--	--	--	--	--
Aroclor 1260	11096-82-5	--	--	--	--	--	--
Aroclor 1262	37324-23-5	--	--	--	--	--	--
Aroclor 1268	11100-14-4	--	--	--	--	--	--
Semivolatile Organic Carbons (SVOCs) (ug/L)							
1,2,4,5-Tetrachlorobenzene	95-94-3	129	--	--	3	1.1	1.1
1,2,4-Trichlorobenzene	120-82-1	5.4 (a)	--	--	30	70	70
1,2-Dichlorobenzene	95-50-1	42 (a)	--	--	14	1300	1300
1,3-Dichlorobenzene	541-73-1	28.5	--	--	38	960	960
1,4-Dichlorobenzene	106-46-7	19.9	--	--	9.4	190	190
2,2'-Oxybis (1-chloropropane)	108-60-1	--	--	--	--	65000	65000
2,3,4,6-Tetrachlorophenol	58-90-2	1.2	--	--	1.2	--	1.2
2,4,5-Trichlorophenol	95-95-4	12	--	--	--	--	12
2,4,6-Trichlorophenol	88-06-2	61	--	--	4.9	2.4	2.4
2,4-Dichlorophenol	120-83-2	11	--	--	11	290	290
2,4-Dimethylphenol	105-67-9	--	--	--	100	850	850
2,4-Dinitrophenol	51-28-5	48.5	--	--	19	5300	5300
2,4-Dinitrotoluene	121-14-2	44	--	--	44	3.4	3.4
2,6-Dinitrotoluene	606-20-2	81	--	--	81	--	81
2-Chloronaphthalene	91-58-7	--	--	--	0.396	1600	1600
2-Chlorophenol	95-57-8	265	--	--	24	150	150
2-Methylphenol (o-Cresol)	95-48-7	1020	--	--	67	--	1020
2-Nitroaniline	88-74-4	--	--	--	--	--	--
2-Nitrophenol	88-75-5	2940	--	--	--	--	2940
3,3'-Dichlorobenzidine	91-94-1	73	--	--	4.5	0.028	0.028
3-Methylphenol & 4-Methylphenol (m&p-Cresol)	1319-77-3	--	--	--	--	--	--
3-Methylphenol (m-Cresol)	108-39-4	--	--	--	62	--	62
3-Nitroaniline	99-09-2	--	--	--	--	--	--
4-Bromophenyl-phenyl ether	101-55-3	1.5	--	--	1.5	--	1.5
4-Chloro-3-methylphenol	59-50-7	--	--	--	34.8	--	34.8
4-Chloroaniline	106-47-8	232	--	--	232	--	232
4-Methylphenol (p-Cresol)	106-44-5	543	--	--	25	--	543
4-Nitroaniline	100-01-6	--	--	--	--	--	--
4-Nitrophenol	100-02-7	71.7	--	--	60	--	71.7
Acetophenone	98-86-2	--	--	--	--	--	--
Aniline	62-53-3	2.2	--	--	4.1	--	2.2
Atrazine	1912-24-9	1.8	--	--	--	--	1.8
Benzaldehyde	100-52-7	--	--	--	--	--	--
Benzidine	92-87-5	3.9	--	--	--	--	3.9
Benzoic acid	65-85-0	42	--	--	--	--	42
Benzyl alcohol	100-51-6	8.6	--	--	8.6	--	8.6
Biphenyl (1,1'-Biphenyl)	92-52-4	14	--	--	--	--	14
bis(2-Chloroethoxy)methane	111-91-1	--	--	--	--	--	--
bis(2-Chloroethyl)ether	111-44-4	--	--	--	19000	0.53	0.53
bis(2-Ethylhexyl)phthalate	117-81-7	16	--	--	0.3	2.2	2.2
Butylbenzyl phthalate	85-68-7	29.4	--	--	23	1900	1900
Caprolactam	105-60-2	--	--	--	--	--	--
Dibenzofuran	132-64-9	65	--	--	4	--	65
Diethyl phthalate	84-66-2	75.9	--	--	110	44000	44000
Dimethyl phthalate	131-11-3	580	--	--	--	1100000	1100000
Di-n-butyl phthalate	84-74-2	3.4	--	--	9.7	4500	4500
Dinitro-o-cresol (4,6-Dinitro-2-methylphenol)	534-52-1	--	--	--	23	280	280
Di-n-octyl phthalate	117-84-0	22	--	--	30	--	22
Hexachlorobenzene	118-74-1	0.0003	--	--	0.0003	0.00029	0.00029
Hexachlorocyclopentadiene	77-47-4	0.07	--	--	77	1100	1100
Hexachloroethane	67-72-1	9.4	--	--	8	3.3	3.3
Isophorone	78-59-1	129	--	--	920	960	960
Nitrobenzene	98-95-3	66.8	--	--	220	690	690
n-Nitrosodimethylamine	62-75-9	330000	--	--	--	--	330000
n-Nitrosodi-n-propylamine	621-64-7	120	--	--	--	0.51	0.51
n-Nitrosodiphenylamine	86-30-6	33000	--	--	--	6	6
Pentachlorophenol	87-86-5	7.9	7.9	13	4	3	3
Phenol	108-95-2	58	--	--	180	860000	860000

Table 3-7 - Development of Initial PRGs for Surface Water

Bremerton Gas Works Site
Bremerton, Washington

Analyte	CAS Number	EPA Region 3 BTAG Marine Water Screening Benchmarks EPA, 2006	National Recommended Water Quality Criteria - Aquatic Life Criteria - Saltwater CCC (chronic)[1] EPA, 2013	National Recommended Water Quality Criteria - Aquatic Life Criteria - Saltwater CMC (acute)[1] EPA, 2013	EPA Region 5 RCRA - Ecological Screening Levels - Water EPA, 2003	National Recommended Water Quality Criteria - Human Health for the Consumption of Organisms EPA, 2013	Initial PRGs used for Data Screening
Volatile Organic Carbons (VOCs) (ug/L)							
1,1,1-Trichloroethane	71-55-6	312	--	--	76	--	312
1,1,1,2-Tetrachloroethane	630-20-6	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	79-34-5	90.2	--	--	380	4	4
1,1,2-Trichloroethane	79-00-5	550	--	--	500	16	16
1,1,2-Trichlorotrifluoroethane (Freon 113)	76-13-1	--	--	--	--	--	--
1,1-Dichloroethane	75-34-3	47	--	--	47	--	47
1,1-Dichloroethene	75-35-4	2240	--	--	65	7100	7100
1,2,3-Trichlorobenzene	87-61-6	8	--	--	--	--	8
1,2,3-Trichloropropane	96-18-4	--	--	--	--	--	--
1,2,4-Trimethylbenzene	95-63-6	19	--	--	--	--	19
1,2-Dibromo-3-chloropropane	96-12-8	--	--	--	--	--	--
1,2-Dichloroethane	107-06-2	1130	--	--	910	37	37
1,2-Dichloroethene, cis-	156-59-2	--	--	--	--	--	--
1,2-Dichloroethene, trans-	156-60-5	970	--	--	970	10000	10000
1,2-Dichloropropane	78-87-5	2400	--	--	360	15	15
1,3,5-Trimethylbenzene (Mesitylene)	108-67-8	71	--	--	--	--	71
1,3-Dichloropropane	142-28-9	--	--	--	--	--	--
1,3-Dichloropropene, cis-	10061-01-5	--	--	--	--	21	21
1,3-Dichloropropene, trans-	10061-02-6	--	--	--	--	21	21
1,4-Dichloro-2-butene, trans-	110-57-6	--	--	--	--	--	--
1,4-Dioxane	123-91-1	--	--	--	22000	--	22000
2-Butanone (MEK)	78-93-3	14000	--	--	2200	--	14000
2-Chlorotoluene	95-49-8	--	--	--	--	--	--
2-Hexanone (Methyl butyl ketone)	591-78-6	99	--	--	99	--	99
4-Chlorotoluene	106-43-4	--	--	--	--	--	--
4-Isopropyltoluene (4-Cymene)	99-87-6	85	--	--	--	--	85
Acetone	67-64-1	564000	--	--	1700	--	564000
Acrolein	107-02-8	0.55	--	--	0.19	--	0.55
Acrylonitrile	107-13-1	581	--	--	66	--	581
Benzene	71-43-2	110 (a)	--	--	114	51	51
Bromobenzene	108-86-1	--	--	--	--	--	--
Bromochloromethane	74-97-5	--	--	--	--	--	--
Bromodichloromethane	75-27-4	--	--	--	--	17	17
Bromoform (Tribromomethane)	75-25-2	640	--	--	230	140	140
Bromomethane (Methyl bromide)	74-83-9	120	--	--	16	1500	1500
Carbon disulfide	75-15-0	0.92	--	--	15	--	0.92
Carbon tetrachloride (Tetrachloromethane)	56-23-5	1500	--	--	240	1.6	1.6
Chlorobenzene	108-90-7	25 (a)	--	--	47	1600	1600
Chloroethane	75-00-3	--	--	--	--	--	--
Chloroform	67-66-3	815	--	--	140	470	470
Chloromethane	74-87-3	2700	--	--	--	--	2700
Cyclohexane	110-82-7	--	--	--	--	--	--
Dibromochloromethane	124-48-1	--	--	--	--	13	13
Dibromomethane	74-95-3	--	--	--	--	--	--
Dichlorodifluoromethane	75-71-8	--	--	--	--	--	--
Dichloromethane (Methylene chloride)	75-09-2	2560	--	--	940	590	590
Ethylbenzene	100-41-4	25 (a)	--	--	14	2100	2100
Ethylene dibromide (1,2-Dibromoethane)	106-93-4	--	--	--	--	--	--
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	87-68-3	0.3	--	--	0.053	18	18
Isopropylbenzene (Cumene)	98-82-8	2.6	--	--	--	--	2.6
Methyl acetate	79-20-9	--	--	--	--	--	--
Methyl iodide (Iodomethane)	74-88-4	--	--	--	--	--	--
Methyl isobutyl ketone (4-Methyl-2-pentanone or (MIBK))	108-10-1	123000	--	--	170	--	123000
Methyl tert-butyl ether (MTBE)	1634-04-4	11070	--	--	--	--	11070
n-Butylbenzene	104-51-8	--	--	--	--	--	--
n-Propylbenzene	103-65-1	128	--	--	--	--	128
o-Xylene	95-47-6	--	--	--	--	--	--
sec-Butylbenzene	135-98-8	--	--	--	--	--	--
Styrene	100-42-5	910	--	--	32	--	910
tert-Butylbenzene	98-06-6	--	--	--	--	--	--
Tetrachloroethene (PCE)	127-18-4	45	--	--	45	3.3	3.3
Toluene	108-88-3	215 (a)	--	--	253	15000	15000
Total xylene (reported, not calculated)	1330-20-7	--	--	--	--	--	--
Total Xylene	--	19	--	--	27	--	19
Trichloroethene (TCE)	79-01-6	21	--	--	47	30	30
Trichlorofluoromethane (Fluorotrichloromethane)	75-69-4	--	--	--	--	--	--
Vinyl acetate	108-05-4	16	--	--	248	--	16
Vinyl chloride	75-01-4	930	--	--	930	2.4	2.4

Notes:

Compounds frequently associated with MGP-operations

'-- indicates not available

1 = Criteria for metals and methyl mercury are expressed in terms of the dissolved metal in the water column.
(a) = This is a Canadian Water Quality Guideline value and refers to the total concentration in an unfiltered sample.
BTAG = Biological Technical Assistance Group
CAS = Chemical Abstract Services
CCC = Criterion Continuous Concentration
CMC = Criterion Maximum Concentration
EPA = U.S. Environmental Protection Agency
HPAH = high molecular weight PAH
LPAH = low molecular weight PAH
L = liter
mg = miligram
MGP = manufactured gas plant
ng = nanogram
PRG = Preliminary Remediation Goal
RCRA = Rsource Conservation and Recovery Act
RSL = regional screening level
ug = microgram

References:

EPA, 2003. EPA Region 5 Resource Conservation Recovery Act (RCRA) Ecological Screening Levels. August 22, 2003.

EPA, 2006. EPA Region 3 Biological Technical Assistance Group (BTAG) Screening Benchmarks. Marine Sediment Benchmarks. July 2006.

EPA, 2013a. National Recommended Water Quality Criteria. Updated August 22, 2013. Available from: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable.

Table 3-8 - Summary of Data Quality Review for Existing Site Data

Bremerton Gas Works Site
Bremerton, Washington

	Study/Media						
	2008 E&E Targeted Brownfields (E&E 2008, E&E 2009)	2010 E&E Removal Action (EPA 2010, AnchorQEA	1995 Ecology (Ecology 1995)	2007 Geoengineers (Geoengineers 2007a, 2007b)	2008 E&E Targeted Brownfields (E&E 2008, E&E 2009)	2007 Geoengineers (Geoengineers 2007a, 2007b)	2008 E&E Targeted Brownfields (E&E 2008, E&E 2009)
	Sediment	Sediment	Soil	Soil	Soil	Groundwater	Groundwater
Work Plan Documentation							
Work Plan (SAP/QAPP)	Detailed QAPP covering multiple pieces of sampling program (soil, groundwater and sediment). Also includes general sediment sampling SOP and data report.	Site-Specific Sampling Plan (SSSP; not reviewed) approved by EPA, finalized after sampling conducted but in field deviations approved by EPA.	None	Work Plan, including site-specific SAP and QAPP, dated June 1, 2007	SQAPP dated March 5, 2008	Work Plan, including site-specific SAP and QAPP, dated June 1, 2007	SQAPP dated March 5, 2008
Collection methods and purpose	Detailed in QAPP. Sampling under EPA Brownfields management, follows EPA procedures. Limited for sediment; to determine if GW migration from upland sources is occurring into the Narrows.	Developed under EPA Superfund Technical Assessment Response Team (START). Determining origin of contamination from 12" exposed drain pipe on Sesko property beach.	Surface soil/sediment samples of suspected contamination based on visual inspection	Purpose to assess soil quality in potential contaminant source areas. Table of rationale for specific boring/sample locations referenced but not included in final work plan.	Judgmental sampling design to determine presence of contamination in areas of concern. Detailed rationale provided in SQAPP.	Purpose to assess groundwater quality in and downgradient of potential contaminant source areas. Table of rationale for specific boring/sample locations referenced but not included in final work plan.	Judgmental sampling design to determine presence of contamination in areas of concern. Detailed rationale provided in SQAPP.
Sample Location and Collection Methods							
Location method, accuracy, and datum.	Location established with GPS coordinates; accuracy not specified. Actual sampling appear to be close/at QAPP locations. Datum not specified.	Location established with GPS coordinates; accuracy not specified. Datum not specified.	Sample locations recorded on rough site sketch. No survey information provided.	Locations provided on scaled site map. Location method unknown. No survey information provided.	Locations provided on scaled site map. Location method unknown. No survey information provided. Note: locations of borings SP01 and SP03 apparently switched on site map, based on boring log information and correlation of chemical data with boring log observations.	Locations provided on scaled site map. Location method unknown. No survey information provided.	Locations provided on scaled site map. Location method unknown. No survey information provided. Note: locations of borings SP01 and SP03 apparently switched on site map, based on boring log information and correlation of chemical data with boring log observations.
Sample depths	0-30cm	0-6 inches	Less than 10 inches	up to 45 feet deep	up to 40 feet deep	15-foot long well screens up to 45 feet deep	Monitoring Wells: 10-foot long well screens up to 45 feet deep. Temporary borings: depth not provided.
Collection method and matrix	Surface sediment. Dedicated stainless steel spoon. Collected at low tide from 5 biased locations targeted to evaluate potential for GW migration based on previous analytical and "on-site observations".	Surface sediment. Dedicated stainless steel spoon. Known areas of sediment deposition within the direct vicinity of the 12: drainpipe, collected below average high tide line.	Hand collection of surface soil/sediment samples	Hollow-stem auger drilling with split-spoon sampling.	Hollow-stem auger drilling with split-spoon sampling.	Report states low-flow sampling with peristaltic pump. Questionable for 30-ft deep groundwater samples.	Monitoring wells sampled using low-flow sampling using electric submersible pump. Methods for sampling temporary boreholes not provided.
Sample collection, processing and handling	Homogenized in dedicated stainless steel bowls (VOC cores taken from sampling locations prior to other sediment collection). Data report includes photographs at each sediment station.	Homogenized in dedicated stainless steel bowls (VOC cores taken from sampling locations prior to other sediment collection). Data report includes photographs at each sediment station.	Collection and handling activities not reported.	Soil samples collected from 8 borings at 5-foot intervals and field screened for contamination. 17 samples collected for sample analysis. VOC samples collected by EPA 5035A. Protocols detailed in SAP.	Soil samples collected from 7 borings at 5-foot intervals and field screened for contamination. 48 samples collected for sample analysis. VOC samples collected by EPA 5035A. Protocols detailed in SAP.	Groundwater samples collected from 8 permanent, developed monitoring wells. Processing and handling protocols detailed in SAP.	Groundwater samples collected from 2 permanent, developed monitoring wells and 4 temporary borings. Processing and handling protocols detailed in SAP.
Holding time, preservation, and chain of custody	Detailed in the QAPP. Chain of custody provided in data report. Holding time and preservation discussed in lab data report.	Chain of custody provided in data report. Holding time and preservation discussed in lab data report.	chain of custody not provided. Laboratory case narrative indicates holding times were within recommended limits.	Requirements detailed in SAP and QAPP. Holding times and preservation were met as documented in data report. Chain of custody provided in data report.	Requirements detailed in SAP and QAPP. Holding times and preservation were met as documented in data report. Chain of custody provided in data report.	Requirements detailed in SAP and QAPP. Holding times and preservation were met as documented in data report. Chain of custody provided in data report.	Requirements detailed in SAP and QAPP. Holding times and preservation were met as documented in data report. Chain of custody provided in data report.
Laboratory Analysis							
Analytical methods are standard or USEPA approved	EPA and NWTPH methods. TPH-Dx, TPH-Dx, VOC, SVOC, TAL metals.	EPA methods. VOC by 8260, SVOC by 8270, static sheen test.	EPA Methods. Metals - EPA200.7, EPA270.2, EPA206.2, EPA279.2, EPA245.5 PAHs - Manchester Modification of SW8270	EPA and NWTPH Methods. TPH - Ecology NWTPH-Gx and NWTPH-Dx VOCs - EPA -8260B SVOCs - EPA 8270 SIM PCBs - EPA 8082 PP metals/chromiumVI - EPA 6000/7000 series TBT - Krone (GC/MS)	TPH - Ecology NWTPH-Gx and NWTPH-Dx VOCs - EPA 8260B SVOCs - EPA 8270C TAL metals - EPA 6000/7000 series	EPA and NWTPH Methods. TPH - Ecology NWTPH-Gx and NWTPH-Dx VOCs - EPA -8260B SVOCs - EPA 8270 SIM PCBs - EPA 8082 PP metals/chromiumVI - EPA 6000/7000 series	EPA and NWTPH Methods. TPH - Ecology NWTPH-Gx and NWTPH-Dx VOCs - EPA 8260B SVOCs - EPA 8270C TAL metals - EPA 6000/7000 series
Detection limits and qualifiers determined based on USEPA guidance	Yes. Detailed in the QAPP. Qualifier identified in laboratory data report.	Yes. Qualifier identified in laboratory data report.	summarized in QA narrative in laboratory data report.	Yes. Detailed in QAPP. Qualifiers identified in laboratory data report.	Yes. Detailed in QAPP. Qualifiers identified in laboratory data report.	Yes. Detailed in QAPP. Qualifiers identified in laboratory data report.	Yes. Detailed in QAPP. Qualifiers identified in laboratory data report.
Measurement instruments and calibration procedures	Detailed in QAPP. Sampling under EPA Brownfields management, follows EPA procedures.	Some detail provided in data validation memo.	Some detail provided in QA narrative in laboratory data report.	Yes. Detailed in QAPP.	Detailed in QAPP. Sampling under EPA Brownfields management, follows EPA procedures.	Yes. Detailed in QAPP.	Detailed in QAPP. Sampling under EPA Brownfields management, follows EPA procedures.
Quality Control and Data Validation							
Field/Lab quality control samples (duplicates, blanks)	Field rinsate and trip blanks (no issues in sediment samples) MS/MSD, serial dilution, internal standards.	Field trip blank.	MS/MSD, LCS	Field duplicate; method blanks, calibration blanks, sample blanks, MS/MSD, and LCS.	Laboratory blanks, rinsate blanks, trip blanks, MS/MSD.	Field duplicate, rinseate blank, and trip blanks; method blanks, calibration blanks, sample blanks, MS/MSD, and LCS.	Laboratory blanks, rinsate blanks, trip blanks, MS/MSD.
Analytical chemistry data must have been validated and qualified consistent with EPA functional guidelines	Data validation conducted. Data validation memo included as Appendix to data report. Procedures also detailed in QAPP.	Data validation conducted. Data validation memo included as Appendix to data report.	QA summary by lab. Compounds with low matrix spike recoveries rejected or "J" qualified.	QA summary by lab.	QA/QC review and data validation documented in data report.	QA summary by lab.	QA/QC review and data validation documented in data report.
Laboratory data reports	Level II Data Package Available.	Level II Data Package Available.	Partial Level II Data Package Available.	Level II Data Package Available	Level II Data Package Available	Level II Data Package Available	Level II Data Package Available

Notes:
COC = chemical of concern
EPA = U.S. Environmental Protection Agency
GC/MS = gas chromatography-mass spectrometry
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NWTPH = Northwest total petroleum hydrocarbon
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PP = priority pollutant
QA = quality assurance
QAPP = Quality Assurance Project Plan
QC = quality control
SAP = Sampling and Analysis Plan
SOP = standard operating procedure
SQAPP = SAP/QAPP
SVOC = semivolatile organic compound
TAL = target analyte list
TBT = tributyltin
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

References:

Washington State Department of Ecology (Ecology), 1995, Initial Investigation Inspection, Sesko Property, March 29, 1995.
GeoEngineers, 2007a, Preliminary Upland Assessment Work Plan, McConkey/Sesko Site, June 1, 2007.
GeoEngineers, 2007b, Preliminary Upland Assessment Report, McConkey/Sesko Brownfield Site, Prepared by GeoEngineers, Inc., for the City of Bremerton, October 26, 2007.
Ecology & Environment, Inc. (E&E), 2008, Final Bremerton Gasworks Targeted Brownfields Assessment Sampling and Quality Assurance Project Plan, Prepared by E&E for EPA, March 5, 2008.
Ecology & Environment, Inc. (E&E), 2009, Final Bremerton Gasworks Targeted Brownfields Assessment Report, Prepared by E&E for U.S. Environmental Protection Agency, August 2009.
Anchor QEA, 2011, Final Completion Report: Former Bremerton MGP Site, Incident Action and Time Critical Removal Action, Prepared for U.S. Coast Guard Sector Puget Sound Incident Management Division on behalf of Cascade Natural Gas Corporation, January 2011.
US Environmental Protection Agency (EPA), 2010 Site-Specific Sampling Plan, Bremerton MGP Release, October 28, 2010.

Table 3-9 - Summary of Data Quality Review for Existing Sediment and Tissue Data

Bremerton Gas Works Site
Bremerton, WA

	Study/Media					
	2010 and 2012 ENVVEST	2005, 2007 NOAA Mussel Watch @ station SIWP	2001 303d Ecology Clam Crab	2008-2009 PSAMP - Spatial/Temporal - Central Sound	1989-2013 PSAMP Long term/ temporal	2009 - PSAMP Urban Waters Initiative - Bainbridge Basin
	Mussel tissue. Data from 11 locations in Dyes Inlet and Sinclair Inlet considered for regional information.	Mussel Tissue. Data from 1 location in Sinclair Inlet considered for regional information.	Clam and crab tissue. Data from 3 locations in Dyes Inlet considered for regional information.	Sediment. Data from 11 locations in Dyes Inlet and Sinclair Inlet considered for regional information.	Sediment. Data from 1 location in Sinclair Inlet considered for regional information.	Sediment. Data from 18 locations in Dyes Inlet and Sinclair Inlet considered for regional information.
Work Plan Documentation						
Work Plan (SAP/QAPP)	Detailed SAP/QAPP developed with EPA and Ecology under the cooperative Environmental Investment (ENVVEST) program (Johnston et al. 2009; 2010).	Detailed SAP/QAPP developed under NOAA National Status and Trends Program (NOAA 1993 and 2006).	Ecology (2001) QAPP. Results summarized in the 2002 data report and queried from EIM.	Detailed programattic QAPP (2009) developed cooperatively with State and Federal agencies. Event-specific addenda (2010, 2011, 2012).	Detailed programattic QAPP (2009) developed cooperatively with State and Federal agencies. Event-specific addenda (2010, 2011, 2012).	Detailed programattic QAPP (2009) developed cooperatively with State and Federal agencies. Event-specific addenda (2010, 2011, 2012) .
Collection methods, purpose and representativeness	Hand collection of blue mussels (Mytilus spp.) via boat or from shore. Shucked, whole organism. Methods follow NOAA protocol. Location control details provided.	Hand collection of blue mussels (Mytilus spp.) via boat or from shore. Shucked, whole organism. Methods follow NOAA protocol.	Hand collection of male cancer crab tissue (Cancer gracilis) via crab pots (though Dungeness and Blue crabs targeted but none found); native and Japanese little neck clam tissue via hand digging (Protothaca staminea and Tapes japonica).	0.1 m2 modified stainless steel van Veen, lowered via cable to open upon sediment contact. Targeted fine grained sediment, sample rejected in field if not fine-grained dominant during in-field visual inspection.	0.1 m2 modified stainless steel van Veen, lowered via cable to open upon sediment contact. Targeted fine grained sediment, sample rejected in field if not fine-grained dominant during in-field visual inspection.	0.1 m2 modified stainless steel van Veen, lowered via cable to open upon sediment contact. Targeted fine grained sediment, sample rejected in field if not fine-grained dominant during in-field visual inspection.
Sample Location and Collection Methods						
Location method, accuracy and datum	Location established with GPS; accuracy not specified. Table provided with coordinates. Datum not specified.	Location established with GPS. Accuracy and datum not specified.	Location established with GPS, accuracy not specified. Table provided with coordinates. Datum is NAD 83.	Location established with differential GPS. with expected accuracy of better than 3 meters. Table provided with coordinates. Datum is NAD 83.	Location established with differential GPS. with expected accuracy of better than 3 meters. Table provided with coordinates. Datum is NAD 83.	Location established with differential GPS. with expected accuracy of better than 3 meters. Table provided with coordinates. Datum is NAD 83.
Sample depths	Above MLLW - on rocks, piling, cabling, piers.	Detailed in NOAA (1993) SAP. Depends on station, some shoreline, some underwater.	Crabs: via pots on surface Clams: via hand digging within 100 sq ft of beach.	Top 2-3cm.	Top 2-3cm.	Top 2-3cm.
Sample collection, processing and handling	<u>Field</u> - Hand harvest, cut byssus threads with knife; hand brush off debris; 1-3 replicates per stations (reps within 150' radius of station loc; 30-50 mussels per replicate. Hand delivery to lab. <u>Lab</u> - kept at -20C until measured and shucked with ceramic knife; rinsed with DI, composite by replicate then by station using Ti blender.	<u>Field</u> - Detailed in NOAA (1993) SAP. In general, some stations hand collection or with rake, some with bivalve dredge. <u>Lab</u> - shell size and volume determined; shucked; homogenized using stainless steel blender with titanium blades. Chemically dried using hydromatrix.	Detailed in SAP.Crabs: Muscle tissue (no organs or shell). Clams: Non depurated. Both crabs and clams samples homogenized in stainless steel blender.	Field - stainless steel spoon from each grab; grabs composited into stainless steel bucket; salinity and sediment temp measured.	Field - stainless steel spoon from each grab; grabs composited into stainless steel bucket; salinity and sediment temp measured.	Field - stainless steel spoon from each grab; grabs composited into stainless steel bucket; salinity and sediment temp measured.
Holding time, preservation, and chain of custody	Requirements detailed in the QAPP. Holding times and preservation were met as documented in the data report. Chain of custody provided in the data report.	Procedures detailed in NOAA (1993) SAP. Actual COCs not available.	Requirements detailed in the QAPP. Holding times and preservation were met as documented in the data report. Chain of custody provided in the data report.	Requirements detailed in the QAPP. Holding times and preservation were met as documented in the data report. Chain of custody provided in the data report.	Requirements detailed in the QAPP. Holding times and preservation were met as documented in the data report. Chain of custody provided in the data report.	Requirements detailed in the QAPP. Holding times and preservation were met as documented in the data report. Chain of custody provided in the data report.
Laboratory Analysis						
Analytical methods are standard or EPA approved	Total Hg - EPA 7473m (EPA 1631 rev E in QAPP). Battelle SOPS for other metals and PCB congeners, PAHs - GC/MS Battelle SOP -015. Standard analytical methods. Lipids, moisture, C and N isotopes, trace metals, Hg, isotopes, 20 NS&T PCB congeners, parent and alkylated PAH.	Lipids, moisture, C and N isotopes, trace metals, Hg, isotopes, 20 NS&T PCB congeners, parent and alkylated PAH. Detailed in specific analytical methods reports. Standard analytical methods.	Lipid, andimony, SVOCs, PAHs. USEPA and PSEP standard anlytical methods.	Grain size, TOC, metals, pesticides, chlorobenzenes, PAHs, phenolics, phthalates, PCBs, PBDEs, bPA, triclosan, and other misc. including HCBD, dibenzofuran, carbazole and tin. EPA and PSEP standard analytical methods.	USEPA and PSEP standard analytical methods.	USEPA and PSEP standard analytical methods.
Detection limits and qualifiers determined based on EPA guidance	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.	Yes. Detailed in QAPP and summarized in QA/QC narrative in data report.
Measurement instruments and calibration procedures	Detailed in QAPP.	Detailed in QAPP.	Detailed in QAPP.	Detailed in QAPP.	Detailed in QAPP.	Detailed in QAPP.
Quality Control and Data Validation						
Field/Lab quality control samples (duplicates, blanks)	B, BS, MS/MSD, LD, reference material.	B, BS, MS/MSD, LD, reference material.	Blank, MS/MSD.	Blind field split replicates, field blanks; lab replicates, MS/MSD, lab control, MB, reference material.	Blind field split replicates, field blanks; lab replicates, MS/MSD, lab control, MB, reference material.	Blind field split replicates, field blanks; lab replicates, MS/MSD, lab control, MB, reference material.
Analytical chemistry data must have been validated and qualified consistent with EPA functional guidelines	Data validation conducted. Details in case narratives.	Not available online.	Data validation conducted. Details in case narratives.	Data validation conducted. Details in case narratives.	Data validation conducted. Details in case narratives.	Data validation conducted. Details in case narratives.
Laboratory data reports	Level II Data Package Available.	Not available online.	Case narrative text only.	Level II Data Package Available.	Only case narratives available through 2000. Online archives incomplete.	Level II Data Package Available.

Notes:
B = Blank
bPA = Bisphenol A
BS = Blank spike
COCs = chemical of concerns
EPA = U.S. Environmental Protection Agency
HCBD = Hexachlorobutadiene
GPS = global positioning system
LCS = Laboratory control sample
MB = Method blank
MS/MSD = Matrix spike/matrix spike duplicate
MLLW = Mean lower-low water
NOAA = National Oceanic and Atmospheric Administration
PAHs = polycyclic aromatic hydrocarbons
PBDE = Polybrominated diphenyl ether
PCBs = polychlorinated biphenyls
PSEP = Puget Sound Estuary Program
QAPP = Quality Assurance Project Plan
QA/QC = quality assurance/quality control
SAP = Sampling and Analysis Plan
SVOC = semivolatile organic compound
TAL = Target analyte list
TOC = Total organic carbon
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

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Table 3-10 - Statistical Summary of Soil Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (mg/kg)	Minimum Detected Concentration (mg/kg)	Soil PRG (mg/kg)	Detected Concentrations Exceeding the PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the PRG	Puget Sound Background Metals Concentration (mg/kg)[1]	Number of Detected Concentrations Exceeding Puget Sound Background	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed Puget Sound Background
TPH	Gasoline Range Hydrocarbons	15	59	11	645	5						
	Diesel Range Hydrocarbons	15	58	10	36000	17.1						
	Oil Range Hydrocarbons	15	58	11	29000	18						
Metals	Aluminum	7	42	42	24100	5780	77000			32600		
	Antimony	13	31	2	1.2	0.8	0.27	2	29	5		12
	Arsenic	15	59	59	48.4	0.5	0.61	55		7	2	
	Barium	7	42	42	120	23.9	330			255		
	Beryllium	15	59	42	0.5	0.1	21			0.6		7
	Cadmium	15	59	34	1.6	0.2	0.36	21	25	1	4	
	Calcium	7	42	42	21300	1620						
	Chromium (Total)	15	59	59	60.8	14.6	26	32		48	11	
	Chromium (VI)	8	17	0	NA	NA	0.29		17			
	Cobalt	7	42	42	19	3.3	13	13		11	15	
	Copper	15	59	59	79.1	8	28	18		36	17	
	Iron	7	42	42	47800	9570	55000			36100	3	
	Lead	15	59	57	246	0.6	11	7		24	6	
	Magnesium	7	42	42	14900	1380						
	Manganese	7	42	42	824	170	220	26		1200		
	Mercury	15	59	14	1.62	0.1	10			0.07	14	45
	Nickel	15	59	59	66.3	21.2	38	27		48	17	
	Potassium	7	42	42	2000	233						
	Selenium	15	59	0	NA	NA	0.52		57	0.78		42
	Silver	15	59	0	NA	NA	4.2			0.61		46
	Sodium	7	42	42	565	120						
	Thallium	15	59	34	5.7	1.1	0.78	34	8			
	Vanadium	7	42	42	86	20.7	7.8	42		45	17	
	Zinc	15	59	59	376	18.9	46	23		85	5	
PAHs	Acenaphthene	18	60	19	31.2	0.0012	3400					
	Acenaphthylene	23	61	23	460	0.00091	682					
	Anthracene	20	61	24	274	0.0012	17000					
	Benzo(g,h,i)perylene	19	61	46	79	0.00071	119					
	Dibenzofuran	15	59	4	0.37	0.017	78		2			
	Fluoranthene	22	61	32	572	0.00068	2300					
	Fluorene	20	61	25	404	0.0007	2300					
	Phenanthrene	24	61	39	1490	0.00061	45.7	6				
	Pyrene	21	61	38	913	0.0006	1700					
	1-Methylnaphthalene	12	17	10	615	0.0144	16	5				
	2-Methylnaphthalene	13	17	10	978	0.0158	230	2				
	Naphthalene	10	12	11	953	0.00047	3.6	4				
cPAHs	Benz(a)anthracene	18	61	29	113	0.0011	0.15	15	2			
	Benzo(a)pyrene	17	61	40	116	0.00053	0.015	21				
	Benzo(b)fluoranthene	17	61	29	57.4	0.00085	0.15	16	1			
	Benzo(k)fluoranthene	17	61	36	60.6	0.00056	1.5	10				
	Chrysene	17	61	35	146	0.00067	15	6				
	Dibenzo(a,h)anthracene	17	61	36	22.8	0.0008	0.015	16	3			
	Indeno(1,2,3-cd)pyrene	17	61	44	58.5	0.00066	0.15	15	1			
	Total cPAHs TEQ (ND = 0)	17	61	50	149	0.000066	0.015	21				
	Total cPAHs TEQ (ND = 1/2 RDL)	17	61	50	149	0.000842	0.015	22				

Table 3-10 - Statistical Summary of Soil Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (mg/kg)	Minimum Detected Concentration (mg/kg)	Soil PRG (mg/kg)	Detected Concentrations Exceeding the PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the PRG	Puget Sound Background Metals Concentration (mg/kg)[1]	Number of Detected Concentrations Exceeding Puget Sound Background	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed Puget Sound Background
Other SVOCs	1,1'-Biphenyl	7	42	5	0.98	0.014	51					
	1,2,4,5-Tetrachlorobenzene	7	42	0	NA	NA	18					
	1,2,4-Trichlorobenzene	15	59	2	0.00023	0.00014	22					
	1,2-Dichlorobenzene	1	1	0	NA	NA	1900					
	1,3-Dichlorobenzene	7	40	0	NA	NA	37.7					
	1,4-Dichlorobenzene	1	1	0	NA	NA	2.4					
	1,4-Dioxane	7	42	0	NA	NA	4.6		2			
	2,3,4,6-Tetrachlorophenol	7	42	0	NA	NA	1800					
	2,4,5-Trichlorophenol	15	59	0	NA	NA	6100					
	2,4,6-Trichlorophenol	15	59	0	NA	NA	44		2			
	2,4-Dichlorophenol	15	59	0	NA	NA	180					
	2,4-Dimethylphenol	15	59	1	0.031	0.031	1200					
	2,4-Dinitrophenol	15	59	0	NA	NA	120		2			
	2-Chloronaphthalene	15	59	0	NA	NA	6300					
	2-Chlorophenol	15	59	0	NA	NA	390					
	2-Methylphenol	8	17	0	NA	NA	3100					
	2-Nitroaniline	15	59	0	NA	NA	610					
	2-Nitrophenol	15	59	0	NA	NA	1.6		8			
	3 & 4 Methylphenol	8	17	0	NA	NA						
	3,3'-Dichlorobenzidine	15	59	0	NA	NA	1.1		17			
	3-Nitroaniline	15	59	0	NA	NA	3.16		7			
	4,6-Dinitro-2-methylphenol	15	59	0	NA	NA	4.9		7			
	4-Bromophenyl phenyl ether	15	59	0	NA	NA						
	4-Chloro-3-methylphenol	15	59	0	NA	NA	6100					
	4-Chloroaniline	15	59	0	NA	NA	2.4		8			
	4-Chlorophenyl phenyl ether	15	59	0	NA	NA						
	4-Methylphenol	7	42	0	NA	NA	6100					
	4-Nitroaniline	15	59	0	NA	NA	24		2			
	4-Nitrophenol	15	59	0	NA	NA	5.12		7			
	Acetophenone	7	42	2	1.5	0.03	7800					
	Aniline	8	17	0	NA	NA	85		2			
	Atrazine	7	42	0	NA	NA	2.1					
	Benzaldehyde	7	42	0	NA	NA	7800					
	Benzidine	7	42	0	NA	NA	0.0005		42			
	Benzoic acid	8	17	0	NA	NA	240000					
	Benzyl alcohol	8	17	0	NA	NA	6100					
	Benzyl butyl phthalate	15	59	5	0.029	0.015	260					
	Bis(2-chloro-1-methylethyl) ether	15	59	0	NA	NA	4.6		4			
	Bis(2-chloroethoxy)methane	15	59	0	NA	NA	180					
	Bis(2-chloroethyl) ether	15	59	0	NA	NA	0.21		17			
	Bis(2-ethylhexyl) phthalate	15	59	39	0.29	0.069	35		2			
	Caprolactam	7	42	1	0.015	0.015	30000					
	Carbazole	15	59	5	0.49	0.019						
	Dibenzofuran	15	59	4	0.37	0.017	78		2			
	Diethyl phthalate	15	59	0	NA	NA	49000					
	Dimethyl phthalate	15	59	0	NA	NA	734					
	Di-n-butyl phthalate	15	59	3	0.016	0.013	6100					
	Di-n-octyl phthalate	15	59	0	NA	NA	610					
	Hexachlorobenzene	15	59	0	NA	NA	0.3		17			
	Hexachlorobutadiene	1	1	0	NA	NA	6.2					

Table 3-10 - Statistical Summary of Soil Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (mg/kg)	Minimum Detected Concentration (mg/kg)	Soil PRG (mg/kg)	Detected Concentrations Exceeding the PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the PRG	Puget Sound Background Metals Concentration (mg/kg)[1]	Number of Detected Concentrations Exceeding Puget Sound Background	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed Puget Sound Background
Other SVOCs (continued)	Hexachlorocyclopentadiene	15	59	0	NA	NA	370					
	Hexachloroethane	15	56	0	NA	NA	12		2			
	Isophorone	15	59	1	6.3	6.3	510					
	Nitrobenzene	8	17	0	NA	NA	4.8		4			
	N-Nitrosodimethylamine	7	42	0	NA	NA	0.0023		42			
	N-Nitroso-di-n-propylamine	15	59	0	NA	NA	0.069		17			
	N-Nitrosodiphenylamine	15	59	0	NA	NA	99		1			
	Pentachlorophenol	15	59	3	0.0036	0.00081	0.89		10			
	Phenol	15	59	6	0.1	0.023	18000					
	2,4-Dinitrotoluene	8	17	0	NA	NA	1.6		8			
	2,6-Dinitrotoluene	8	17	0	NA	NA	0.0328		17			
VOCs	1,1,1,2-Tetrachloroethane	15	59	0	NA	NA	1.9		2			
	1,1,1-Trichloroethane	15	59	0	NA	NA	8700					
	1,1,2 - Trichlorotrifluoroethane	7	42	0	NA	NA	43000					
	1,1,2,2-Tetrachloroethane	15	59	0	NA	NA	0.56		3			
	1,1,2-Trichloroethane	15	59	0	NA	NA	1.1		2			
	1,1-Dichloroethane	15	59	0	NA	NA	3.3		2			
	1,1-Dichloroethene	15	57	0	NA	NA	240					
	1,1-Dichloropropene	8	17	0	NA	NA						
	1,2,3-Trichlorobenzene	15	59	6	0.00017	0.00013	49					
	1,2,3-Trichloropropane	15	59	0	NA	NA	0.005		11			
	1,2,4-Trimethylbenzene	15	59	9	13.2	0.014	62					
	1,2-Dibromo-3-chloropropane	15	59	0	NA	NA	0.0054		18			
	1,2-Dibromoethane (EDB)	15	59	0	NA	NA	0.034		11			
	1,2-Dichloroethane (EDC)	15	59	0	NA	NA	0.43		4			
	1,2-Dichloropropane	15	58	0	NA	NA	0.94		2			
	1,3,5-Trimethylbenzene	15	59	8	5.5	0.026	780					
	1,3-Dichlorobenzene	7	40	0	NA	NA	37.7					
	1,3-Dichloropropane	8	17	0	NA	NA	1600					
	1,4-Difluorobenzene	1	1	1	2	2						
	2,2-Dichloropropane	8	17	0	NA	NA						
	2-Butanone	15	59	2	2.4	0.015	28000					
	2-Chlorotoluene	8	17	0	NA	NA	1600					
	2-Hexanone	15	59	0	NA	NA	12.6		2			
	4-Chlorotoluene	8	17	0	NA	NA	1600					
	4-Methyl-2-pentanone	15	59	0	NA	NA	5300					
	Acetone	15	59	30	0.064	0.0065	61000					
	Benzene	15	59	22	12	0.00069	1.1	3				
	Bromobenzene	8	17	0	NA	NA	300					
	Bromochloromethane	15	59	0	NA	NA	160					
	Bromodichloromethane	15	59	0	NA	NA	0.27		5			
	Bromoform	15	59	0	NA	NA	15.9					
	Bromomethane	15	58	0	NA	NA	7.3					
	Carbon disulfide	15	59	4	0.0075	0.0043	820					
	Carbon tetrachloride	15	59	0	NA	NA	0.61		2			
	Chlorobenzene	15	59	0	NA	NA	290					
	Chlorobenzene-d5	1	1	1	2	2						
	Chloroethane	15	59	0	NA	NA	15000					
	Chloroform	15	59	3	0.044	0.00048	0.29		5			
	Chloromethane	15	59	0	NA	NA	120					

Table 3-11 - Statistical Summary of Groundwater Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/L)	Minimum Detected Concentration (ug/L)	Groundwater PRG (ug/L)	Number of Detected Concentrations Exceeding the Groundwater PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Groundwater PRG	Surface Water PRG (ug/L)	Number of Detected Concentrations Exceeding the Surface Water PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Surface Water PRG
TPH	Gasoline Range Hydrocarbons	10	10	7	10600	63.5						
	Diesel Range Hydrocarbons	11	11	6	18500	170						
	Oil Range Hydrocarbons	11	11	1	160	160						
Metals (Total)	Antimony	10	10	2	0.4	0.3	6			640		
	Arsenic	10	10	10	26	0.6	0.045	10		0.14	10	
	Barium	2	2	2	173	35.7	2000					
	Beryllium	10	10	3	1.08	0.37	4			0.66	2	7
	Cadmium	10	10	2	0.16	0.05	5			8.8		
	Chromium (Total)	10	10	10	228	1.34	100	2		42	3	
	Chromium (VI)	8	8	7	90	6	0.031	7	1	50	2	
	Cobalt	2	2	2	8.3	1.4	4.7	1				
	Copper	10	10	10	143	1.05	620			3.1	8	
	Lead	10	10	8	21.6	0.44	15	2		8.1	2	
	Manganese	2	2	2	3020	98.1	320	1				
	Mercury	8	8	1	0.246	0.246	0.63			0.94		
	Nickel	10	10	10	232	1.65	300			8.2	7	
	Selenium	10	10	1	3.64	3.64	50			71		
	Silver	10	10	1	0.07	0.07	71			1.9		
	Thallium	10	10	1	0.26	0.26	0.16	1	9	0.47		9
	Vanadium	2	2	2	78.2	3.7	63	1				
	Zinc	10	10	8	185	4.5	4700			81	2	
PAHs	Acenaphthene	9	9	5	485	1.1	400	1		990		
	Acenaphthylene	10	10	6	34.9	0.222				4840		
	Anthracene	10	10	5	120	0.4	1300			40000		
	Benzo(g,h,i)perylene	10	10	5	25.6	0.0979				7.64	1	
	Dibenzofuran	10	10	2	31.8	0.29	5.8	1	7	4	1	7
	Fluoranthene	10	10	6	122	0.26	630			140		
	Fluorene	10	10	7	184	0.102	220			5300		
	Phenanthrene	10	10	5	377	1.04				1.5	3	
	Pyrene	10	10	7	34.5	0.174	87			4000		
	1-Methylnaphthalene	8	8	4	970	0.813	0.97	3	1	2.1	3	1
	2-Methylnaphthalene	10	10	6	1430	0.13	27	1		4.2	1	
	Naphthalene	2	2	0	NA	NA	0.14			13		
cPAHs	Benz(a)anthracene	10	10	6	39.3	0.0168	0.029	5	2	0.018	5	2
	Benzo(a)pyrene	10	10	6	37.6	0.0247	0.0029	6	4	0.018	6	2
	Benzo(b)fluoranthene	10	10	4	0.657	0.0968	0.029	4	3	0.018	4	3
	Benzo(k)fluoranthene	10	10	5	0.615	0.0602	0.29	2	1	0.018	5	3
	Chrysene	10	10	6	40.8	0.0372	2.9	1		0.018	6	2
	Dibenzo(a,h)anthracene	10	10	4	0.189	0.0437	0.0029	4	6	0.018	4	3
	Indeno(1,2,3-cd)pyrene	10	10	4	0.467	0.0874	0.029	4	3	0.018	4	3
	Total cPAHs TEQ (ND = 0)	10	10	6	41.9	0.0328	0.0029	6				
	Total cPAHs TEQ (ND = 1/2 RDL)	10	10	6	43.8	0.0342	0.0029	6				

Table 3-11 - Statistical Summary of Groundwater Data
Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/L)	Minimum Detected Concentration (ug/L)	Groundwater PRG (ug/L)	Number of Detected Concentrations Exceeding the Groundwater PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Groundwater PRG	Surface Water PRG (ug/L)	Number of Detected Concentrations Exceeding the Surface Water PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Surface Water PRG
Other SVOCs	1,1'-Biphenyl	2	2	0	NA	NA	0.83			14		
	1,2,4,5-Tetrachlorobenzene	2	2	0	NA	NA	1.2			1.1		
	1,2,4-Trichlorobenzene	10	10	0	NA	NA	0.99		8	70		
	1,2,4-Trimethylbenzene	1	1	0	NA	NA	15			19		
	1,2-Dichlorobenzene	10	10	0	NA	NA	280			1300		
	1,3-Dichlorobenzene	10	10	0	NA	NA				960		
	1,4-Dichlorobenzene	10	10	0	NA	NA	0.42			190		
Other SVOCs (continued)	2,3,4,6-Tetrachlorophenol	2	2	0	NA	NA	170			1.2		
	2,4,5-Trichlorophenol	10	10	0	NA	NA	890			12		
	2,4,6-Trichlorophenol	10	10	0	NA	NA	3.5		8	2.4		8
	2,4-Dichlorophenol	10	10	0	NA	NA	35			290		
	2,4-Dimethylphenol	10	10	0	NA	NA	270			850		
	2,4-Dinitrophenol	10	10	0	NA	NA	30			5300		
	2-Chloronaphthalene	10	10	0	NA	NA	550			1600		
	2-Chlorophenol	10	10	0	NA	NA	71			150		
	2-Methylphenol	8	8	0	NA	NA	720			67		
	2-Nitroaniline	10	10	0	NA	NA	150					
	2-Nitrophenol	10	10	0	NA	NA				2940		
	3 & 4 Methylphenol	8	8	0	NA	NA	1400					
	3,3'-Dichlorobenzidine	10	10	0	NA	NA	0.11		10	0.028		10
	3-Nitroaniline	10	10	0	NA	NA						
	4,6-Dinitro-2-methylphenol	10	10	0	NA	NA	1.2		8	280		
	4-Bromophenyl phenyl ether	10	10	0	NA	NA				1.5		8
	4-Chloro-3-methylphenol	10	10	0	NA	NA	1100			34.8		
	4-Chloroaniline	10	10	0	NA	NA	0.32		10	232		
	4-Chlorophenyl phenyl ether	10	10	0	NA	NA						
	4-Methylphenol	2	2	0	NA	NA	1400			25		
	4-Nitroaniline	10	10	0	NA	NA	3.3		8			
	4-Nitrophenol	10	10	0	NA	NA				60		
	Acenaphthene	9	9	5	485	1.1	400	1		990		
	Acetophenone	2	2	0	NA	NA	1500					
	Aniline	8	8	0	NA	NA	12			2.2		8
	Atrazine	2	2	0	NA	NA	0.26		2	1.8		
	Benzaldehyde	2	2	0	NA	NA	1500					
	Benzidine	2	2	0	NA	NA	0.000092		2	3.9		
	Benzoic acid	8	8	0	NA	NA	58000			42		
	Benzyl alcohol	8	8	0	NA	NA	1500			8.6		8
	Benzyl butyl phthalate	10	10	1	0.33	0.33	14			1900		
	Bis(2-chloro-1-methylethyl) ether	10	10	0	NA	NA	0.31		10	65000		
	Bis(2-chloroethoxy)methane	10	10	0	NA	NA	46					
	Bis(2-chloroethyl) ether	10	10	0	NA	NA	0.012		10	0.53		8
	Bis(2-ethylhexyl) phthalate	10	10	2	0.5	0.33	4.8		8	2.2		8
	Caprolactam	2	2	1	0.71	0.71	7700					
	Carbazole	10	10	1	1.3	1.3						
	Diethyl phthalate	10	10	0	NA	NA	11000			44000		
	Dimethyl phthalate	10	10	0	NA	NA				1100000		
	Di-n-butyl phthalate	10	10	0	NA	NA	670			4500		
	Di-n-octyl phthalate	10	10	0	NA	NA	160			22		
	Hexachlorobenzene	10	10	0	NA	NA	0.042		10	0.00029		10
	Hexachlorobutadiene	10	10	0	NA	NA	0.26		8	18		
	Hexachlorocyclopentadiene	10	10	0	NA	NA	22			1100		
	Hexachloroethane	10	10	0	NA	NA	0.79		8	3.3		8
	Isophorone	10	10	0	NA	NA	67			960		
	Nitrobenzene	8	8	0	NA	NA	0.12		8	690		
	N-Nitrosodimethylamine	2	2	0	NA	NA	0.00042		2	330000		
	N-Nitroso-di-n-propylamine	10	10	0	NA	NA	0.0093		10	0.51		8
	N-Nitrosodiphenylamine	10	10	0	NA	NA	10		1	6		8
	Pentachlorophenol	10	10	2	11.4	0.1	0.035	2	8	3	1	7
	Phenol	10	10	3	81.6	75.5	4500			860000		
	2,4-Dinitrotoluene	8	8	0	NA	NA	0.2		8	3.4		8
	2,6-Dinitrotoluene	8	8	0	NA	NA	0.042		8	81		
	2-Methylnaphthalene	10	10	6	1430	0.13	27	1		4.2	1	

Table 3-11 - Statistical Summary of Groundwater Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/L)	Minimum Detected Concentration (ug/L)	Groundwater PRG (ug/L)	Number of Detected Concentrations Exceeding the Groundwater PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Groundwater PRG	Surface Water PRG (ug/L)	Number of Detected Concentrations Exceeding the Surface Water PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Surface Water PRG
VOCs	1,1,1,2-Tetrachloroethane	10	10	0	NA	NA	0.5					
	1,1,1-Trichloroethane	10	10	0	NA	NA	200			76		
	1,1,2 - Trichlorotrifluoroethane	2	2	0	NA	NA	53000					
	1,1,2,2-Tetrachloroethane	10	10	0	NA	NA	0.066		10	4		
	1,1,2-Trichloroethane	10	10	0	NA	NA	0.24		2	16		
	1,1-Dichloroethane	10	10	0	NA	NA	2.4			47		
	1,1-Dichloroethene	9	9	0	NA	NA	7			7100		
	1,1-Dichloropropene	8	8	0	NA	NA						
	1,2,3-Trichlorobenzene	10	10	0	NA	NA	5.2			8		
	1,2,3-Trichloropropane	10	10	0	NA	NA	0.00065		10			
	1,2,4-Trichlorobenzene	10	10	0	NA	NA	0.99		8	70		
	1,2,4-Trimethylbenzene	1	1	0	NA	NA	15			19		
	1,2-Dibromo-3-chloropropane	10	10	0	NA	NA	0.00032		10			
	1,2-Dibromoethane (EDB)	10	10	0	NA	NA	0.0065		10			
	1,2-Dichlorobenzene	10	10	0	NA	NA	280			1300		
	1,2-Dichloroethane (EDC)	10	10	3	4.72	0.93	0.15	3	7	37		
	1,2-Dichloropropane	10	10	0	NA	NA	0.38			15		
	1,3,5-Trimethylbenzene	10	10	5	30	0.53	87			71		
	1,3-Dichlorobenzene	10	10	0	NA	NA				960		
	1,3-Dichloropropane	8	8	0	NA	NA	290					
	1,4-Dichlorobenzene	10	10	0	NA	NA	0.42			190		
	2,2-Dichloropropane	8	8	0	NA	NA						
	2-Butanone	10	10	0	NA	NA	4900			2200		
	2-Chlorotoluene	8	8	0	NA	NA	180					
	2-Hexanone	10	10	0	NA	NA	34			99		
	4-Chlorotoluene	8	8	0	NA	NA	190					
	4-Methyl-2-pentanone	10	10	0	NA	NA	1000			170		
	Acetone	10	10	0	NA	NA	12000			1700		
	Benzene	10	10	8	950	2.23	0.39	8		51	5	
	Bromobenzene	8	8	0	NA	NA	54					
	Bromochloromethane	10	10	0	NA	NA	83					
	Bromodichloromethane	10	10	0	NA	NA	0.12		10	17		
	Bromoform	10	10	0	NA	NA	7.9			140		
	Bromomethane	10	10	0	NA	NA	7			1500		
	Carbon disulfide	10	10	0	NA	NA	720			0.92		
	Carbon tetrachloride	10	10	1	0.66	0.66	0.39	1		1.6		
	Chlorobenzene	10	10	0	NA	NA	72			1600		
	Chloroethane	10	10	0	NA	NA	21000					
	Chloroform	10	10	3	2.84	0.2	0.19	3	7	470		
	Chloromethane	10	10	0	NA	NA	190			2700		
	cis-1,2-Dichloroethene (DCE)	10	10	3	1.29	0.37	28					
	cis-1,3-Dichloropropene	10	10	0	NA	NA				21		
	Cyclohexane	2	2	1	0.38	0.38	13000					
	Dibromochloromethane	10	10	0	NA	NA	0.15		10	13		
	Dibromomethane	8	8	0	NA	NA	7.9					
	Dichlorodifluoromethane	10	10	0	NA	NA	190					
	Ethylbenzene	10	10	7	322	0.53	1.3	6		2100		
	Hexachlorobutadiene	10	10	0	NA	NA	0.26		8	18		
	Hexachloroethane	10	10	0	NA	NA	0.79		8	3.3		8
	Isopropylbenzene	10	10	6	37.4	3	390			2.6	6	
	Methyl acetate	2	2	0	NA	NA	16000					
	Methyl tert-butyl ether (MTBE)	10	10	0	NA	NA	12			11070		
	Methylcyclohexane	2	2	0	NA	NA						
	Methylene chloride	10	10	0	NA	NA	5			590		
	n-Butylbenzene	8	8	4	5.3	0.48	780					
	n-Hexane	8	8	1	1.17	1.17	250			0.58	1	7

Table 3-11 - Statistical Summary of Groundwater Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/L)	Minimum Detected Concentration (ug/L)	Groundwater PRG (ug/L)	Number of Detected Concentrations Exceeding the Groundwater PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Groundwater PRG	Surface Water PRG (ug/L)	Number of Detected Concentrations Exceeding the Surface Water PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Surface Water PRG
VOCs (continued)	n-Propylbenzene	8	8	4	9.2	2.38	530			128		
	p-Isopropyltoluene	8	8	4	8.44	0.27				85		
	sec-Butylbenzene	8	8	5	4.43	0.32	1600					
	Styrene	10	10	0	NA	NA	100			32		
	tert-Butylbenzene	8	8	0	NA	NA	510					
	Tetrachloroethene (PCE)	10	10	0	NA	NA	5			3.3		
	Toluene	10	10	6	41.9	0.45	860			15000		
	trans-1,2-Dichloroethene	10	10	0	NA	NA	86			10000		
	trans-1,3-Dichloropropene	10	10	0	NA	NA				21		
	Trichloroethene (TCE)	10	10	6	4.79	0.33	0.44	4		30		
	Trichlorofluoromethane	10	10	0	NA	NA	1100					
	Vinyl chloride	10	10	0	NA	NA	0.015		10	2.4		
	m,p-Xylenes	10	10	6	383	0.74	190	1				
	o-Xylene	10	10	6	211	4.91	190	1				
	Xylenes (total)	8	8	5	593	8.29	190	2		19	4	
PCBs	Aroclor 1016	8	8	0	NA	NA	0.96					
	Aroclor 1221	8	8	0	NA	NA	0.004		8			
	Aroclor 1232	8	8	0	NA	NA	0.004		8			
	Aroclor 1242	8	8	0	NA	NA	0.034		8			
	Aroclor 1248	8	8	0	NA	NA	0.034		8			
	Aroclor 1254	8	8	0	NA	NA	0.034		8			
	Aroclor 1260	8	8	0	NA	NA	0.034		8			
	Aroclor 1262	8	8	0	NA	NA						
	Aroclor 1268	8	8	0	NA	NA						

Notes:

cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NA = Not applicable, as there are no detections.
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PRG = preliminary remediation goal
SVOCs = semi-volatile organic compounds
TPH = total petroleum hydrocarbons
ug/L = micrograms per liter
VOCs = volatile organic compounds

Table 3-11 - Statistical Summary of Groundwater Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/L)	Minimum Detected Concentration (ug/L)	Groundwater PRG (ug/L)	Number of Detected Concentrations Exceeding the Groundwater PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Groundwater PRG	Surface Water PRG (ug/L)	Number of Detected Concentrations Exceeding the Surface Water PRG	Number of Non-Detect Results with Reporting Limit Concentrations that Exceed the Surface Water PRG
VOCs (continued)	n-Propylbenzene	8	8	4	9.2	2.38	530			128		
	p-Isopropyltoluene	8	8	4	8.44	0.27				85		
	sec-Butylbenzene	8	8	5	4.43	0.32	1600					
	Styrene	10	10	0	NA	NA	100			32		
	tert-Butylbenzene	8	8	0	NA	NA	510					
	Tetrachloroethene (PCE)	10	10	0	NA	NA	5			3.3		
	Toluene	10	10	6	41.9	0.45	860			15000		
	trans-1,2-Dichloroethene	10	10	0	NA	NA	86			10000		
	trans-1,3-Dichloropropene	10	10	0	NA	NA				21		
	Trichloroethene (TCE)	10	10	6	4.79	0.33	0.44	4		30		
	Trichlorofluoromethane	10	10	0	NA	NA	1100					
	Vinyl chloride	10	10	0	NA	NA	0.015		10	2.4		
	m,p-Xylenes	10	10	6	383	0.74	190	1				
	o-Xylene	10	10	6	211	4.91	190	1				
	Xylenes (total)	8	8	5	593	8.29	190	2		19	4	
PCBs	Aroclor 1016	8	8	0	NA	NA	0.96					
	Aroclor 1221	8	8	0	NA	NA	0.004		8			
	Aroclor 1232	8	8	0	NA	NA	0.004		8			
	Aroclor 1242	8	8	0	NA	NA	0.034		8			
	Aroclor 1248	8	8	0	NA	NA	0.034		8			
	Aroclor 1254	8	8	0	NA	NA	0.034		8			
	Aroclor 1260	8	8	0	NA	NA	0.034		8			
	Aroclor 1262	8	8	0	NA	NA						
	Aroclor 1268	8	8	0	NA	NA						

Notes:

cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NA = Not applicable, as there are no detections.
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PRG = preliminary remediation goal
SVOCs = semi-volatile organic compounds
TPH = total petroleum hydrocarbons
ug/L = micrograms per liter
VOCs = volatile organic compounds

Table 3-12 - Statistical Summary of Sediment Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/kg)	Minimum Detected Concentration (ug/kg)	Sediment PRG (ug/kg)	Puget Sound Background Sediment Metals Concentration[1] (ug/kg)	Number of Detected Concentrations Exceeding the PRG	Number of Detected Concentrations Exceeding Puget Sound Background Metals Concentration
TPH	Gasoline Range Hydrocarbons	5	5	0	NA	NA				
	Diesel Range Hydrocarbons	5	5	4	240000	63000				
	Oil Range Hydrocarbons	5	5	5	620000	21000				
Metals	Aluminum	5	5	5	9030000	6020000				
	Antimony	1	1	1	3900	3900	2000	5000	1	
	Arsenic	5	5	5	5100	1500	57000	11000		
	Barium	5	5	5	47000	13300				
	Beryllium	5	5	5	2700	1900				
	Cadmium	5	5	0	NA	NA	5100	1000		
	Calcium	5	5	5	33600000	2390000				
	Chromium (Total)	5	5	5	21200	16600	260000	62000		
	Cobalt	5	5	5	26300	3000	50000	11000		
	Copper	5	5	5	71700	8600	390000	44000		
	Iron	5	5	5	15900000	9730000	20000000			
	Lead	5	5	5	30000	8900	450000	21000		
	Magnesium	5	5	5	4640000	3350000				
	Manganese	5	5	5	180000	135000	460000			
	Mercury	3	3	3	100	27.8	410	200		
	Nickel	5	5	5	52600	21400	20900	50000	5	1
	Potassium	5	5	5	603000	415000				
	Selenium	5	5	1	400	400	2000	780		
	Silver	5	5	0	NA	NA	6100	300		
	Sodium	5	5	5	1930000	605000				
	Thallium	5	5	0	NA	NA				
	Vanadium	5	5	5	36500	21600		45000		
	Zinc	5	5	5	79900	23200	410000	93000		
PAHs	Acenaphthene	48	63	61	160000	0.4	500		16	
	Acenaphthylene	51	66	66	840000	0.7	1300		33	
	Anthracene	51	66	66	680000	0.3	960		41	
	Benzo(g,h,i)perylene	51	66	66	260000	0.9	670		50	
	Dibenzofuran	5	5	4	74	58	540			
	Fluoranthene	46	61	61	1100000	1.6	1700		45	
	Fluorene	51	66	65	600000	0.3	540		36	
	Phenanthrene	51	66	66	1700000	2.6	1500		46	
	Pyrene	51	66	66	1400000	1.6	2600		48	
	2-Methylnaphthalene	5	5	5	1200	19	670		1	
	Naphthalene	46	61	61	1700000	5.4	2100		23	
	Benz(a)anthracene	51	66	66	310000	0.3	1300		46	
	Benzo(a)pyrene	51	66	66	400000	0.5	1600		47	
	Benzo(b)fluoranthene	51	66	66	200000	0.4	10400		17	
	Benzo(k)fluoranthene	51	66	65	93000	0.5	240		50	
	Chrysene	51	66	66	270000	0.5	1400		47	
	Dibenzo(a,h)anthracene	51	66	65	38000	0.2	230		46	
	Indeno(1,2,3-cd)pyrene	51	66	66	190000	0.4	600		49	
	Total cPAHs TEQ (ND = 0)	51	66	66	509200	0.6	1600		49	
	Total cPAHs TEQ (ND = 1/2 RDL)	51	66	66	509200	0.9	1600		49	
	Total HPAHs	46	61	61	4361000	6.2	12000		45	
	Total LPAHs	46	61	61	5596000	10.1	5200		39	
	Total PAHs	46	61	61	8890000	16.3	4022		48	

Table 3-12 - Statistical Summary of Sediment Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/kg)	Minimum Detected Concentration (ug/kg)	Sediment PRG (ug/kg)	Puget Sound Background Sediment Metals Concentration[1] (ug/kg)	Number of Detected Concentrations Exceeding the PRG	Number of Detected Concentrations Exceeding Puget Sound Background Metals Concentration
	1,1'-Biphenyl	5	5	4	110	60	1220			
	1,2,4,5-Tetrachlorobenzene	5	5	0	NA	NA	47000			
	1,2,4-Trichlorobenzene	8	9	0	NA	NA	31			
	1,2-Dichlorobenzene	8	9	0	NA	NA	35			
	1,3,5-Trimethylbenzene	1	1	1	21	21				
	1,3-Dichlorobenzene	5	5	0	NA	NA	842			
	1,4-Dichlorobenzene	2	2	2	23	22	110			
	1,4-Dioxane	5	5	0	NA	NA	119			
	2,3,4,6-Tetrachlorophenol	5	5	0	NA	NA	284			
	2,4,5-Trichlorophenol	5	5	0	NA	NA	819			
	2,4,6-Trichlorophenol	5	5	0	NA	NA	2650			
	2,4-Dichlorophenol	5	5	0	NA	NA	117			
	2,4-Dimethylphenol	5	5	0	NA	NA	29			
	2,4-Dinitrophenol	5	5	0	NA	NA	6.21			
	2-Chloronaphthalene	5	5	0	NA	NA	417			
	2-Chlorophenol	5	5	0	NA	NA	344			
	2-Nitroaniline	5	5	0	NA	NA				
	2-Nitrophenol	5	5	0	NA	NA				
	3,3'-Dichlorobenzidine	5	5	0	NA	NA	2060			
	3-Nitroaniline	5	5	0	NA	NA				
	4,6-Dinitro-2-methylphenol	5	5	0	NA	NA	104			
	4-Bromophenyl phenyl ether	5	5	0	NA	NA	1230			
	4-Chloro-3-methylphenol	5	5	0	NA	NA	388			
	4-Chloroaniline	5	5	0	NA	NA	146			
Other SVOCs	4-Chlorophenyl phenyl ether	5	5	0	NA	NA				
	4-Methylphenol	5	5	2	17	17	670			
	4-Nitroaniline	5	5	0	NA	NA				
	4-Nitrophenol	5	5	0	NA	NA	13.3			
	Acenaphthene	48	63	61	160000	0.4	500		16	
	Acetophenone	5	5	0	NA	NA				
	Atrazine	5	5	0	NA	NA	6.62			
	Benzaldehyde	5	5	2	38	19				
	Benzidine	5	5	0	NA	NA				
	Benzyl butyl phthalate	5	5	0	NA	NA	63			
	Bis(2-chloro-1-methylethyl) ethe	5	5	0	NA	NA				
	Bis(2-chloroethoxy)methane	5	5	0	NA	NA				
	Bis(2-chloroethyl) ether	5	5	0	NA	NA	3520			
	Bis(2-ethylhexyl) phthalate	5	5	1	42	42	1300			
	Caprolactam	5	5	0	NA	NA				
	Carbazole	5	5	4	110	69				
	Dibenzofuran	5	5	4	74	58	540			
	Diethyl phthalate	5	5	0	NA	NA	200			
	Dimethyl phthalate	5	5	0	NA	NA	71			
	Di-n-butyl phthalate	5	5	0	NA	NA	1400			
	Di-n-octyl phthalate	5	5	0	NA	NA	6200			
	Hexachlorobenzene	5	5	0	NA	NA	22			
	Hexachlorobutadiene	8	9	0	NA	NA	11			
	Hexachlorocyclopentadiene	5	5	0	NA	NA	139			
	Hexachloroethane	3	3	0	NA	NA	804			
	Isophorone	5	5	0	NA	NA	432			
	Naphthalene	46	61	61	1700000	5.4	2100		23	

Table 3-12 - Statistical Summary of Sediment Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/kg)	Minimum Detected Concentration (ug/kg)	Sediment PRG (ug/kg)	Puget Sound Background Sediment Metals Concentration[1] (ug/kg)	Number of Detected Concentrations Exceeding the PRG	Number of Detected Concentrations Exceeding Puget Sound Background Metals Concentration
Other SVOCs (continued)	N-Nitrosodimethylamine	5	5	0	NA	NA				
	N-Nitroso-di-n-propylamine	5	5	0	NA	NA				
	N-Nitrosodiphenylamine	5	5	0	NA	NA	28			
	Pentachlorophenol	5	5	5	110	35	360			
	Phenol	5	5	0	NA	NA	420			
	2-Methylnaphthalene	5	5	5	1200	19	670		1	
VOCs	1,1,1,2-Tetrachloroethane	8	9	0	NA	NA				
	1,1,1-Trichloroethane	8	9	0	NA	NA	856			
	1,1,2 - Trichlorotrifluoroethane	8	9	0	NA	NA				
	1,1,2,2-Tetrachloroethane	8	9	0	NA	NA	202			
	1,1,2-Trichloroethane	8	9	0	NA	NA	570			
	1,1-Dichloroethane	8	9	0	NA	NA	0.575			
	1,1-Dichloroethene	8	9	0	NA	NA	2780			
	1,1-Dichloropropene	3	4	0	NA	NA				
	1,2,3-Trichlorobenzene	8	9	0	NA	NA	858			
	1,2,3-Trichloropropane	8	9	0	NA	NA				
	1,2,4-Trichlorobenzene	8	9	0	NA	NA	31			
	1,2,4-Trimethylbenzene	8	9	4	980	2.4				
	1,2-Dibromo-3-chloropropane	8	9	0	NA	NA				
	1,2-Dibromoethane (EDB)	8	9	0	NA	NA				
	1,2-Dichlorobenzene	8	9	0	NA	NA	35			
	1,2-Dichloroethane (EDC)	8	9	0	NA	NA	260			
	1,2-Dichloropropane	8	9	0	NA	NA	333			
	1,3,5-Trimethylbenzene	1	1	1	21	21				
	1,3-Dichlorobenzene	5	5	0	NA	NA	842			
	1,3-Dichloropropane	3	4	0	NA	NA				
	1,4-Dichloro-2-Butene	3	4	0	NA	NA				
	1,4-Dichlorobenzene	2	2	2	23	22	110			
	2,2-Dichloropropane	3	4	0	NA	NA				
	2-Butanone	8	9	0	NA	NA	42.4			
	2-Chloroethyl Vinyl Ether	3	4	0	NA	NA				
	2-Chlorotoluene	3	4	0	NA	NA				
	2-Hexanone	8	9	0	NA	NA	58.2			
	4-Chlorotoluene	3	4	0	NA	NA				
	4-Methyl-2-pentanone	8	9	0	NA	NA	25.1			
	Acrolein	3	4	0	NA	NA	0.00152			
	Acrylonitrile	3	4	0	NA	NA	1.2			
	Benzene	8	9	3	8.1	1.5	137			
	Bromobenzene	3	4	0	NA	NA				
	Bromochloromethane	8	9	0	NA	NA				
	Bromodichloromethane	8	9	0	NA	NA				
	Bromoethane	3	4	0	NA	NA				
	Bromoform	8	9	0	NA	NA	1310			
	Bromomethane	8	9	0	NA	NA	1.37			
	Carbon disulfide	8	9	1	4.3	4.3	0.851		1*	
	Carbon tetrachloride	8	9	0	NA	NA	7240			
	Chlorobenzene	8	9	0	NA	NA	162			
	Chloroethane	8	9	0	NA	NA				
	Chloroform	8	9	0	NA	NA	121			
	Chloromethane	8	9	0	NA	NA				
	cis-1,2-Dichloroethene (DCE)	8	9	0	NA	NA				

Table 3-12 - Statistical Summary of Sediment Data

Bremerton Gas Works Site
Bremerton, Washington

Chemical Group	Chemical Constituent	Number of Locations	Number of Samples	Number of Detections	Maximum Detected Concentration (ug/kg)	Minimum Detected Concentration (ug/kg)	Sediment PRG (ug/kg)	Puget Sound Background Sediment Metals Concentration[1] (ug/kg)	Number of Detected Concentrations Exceeding the PRG	Number of Detected Concentrations Exceeding Puget Sound Background Metals Concentration
VOCs (continued)	cis-1,3-Dichloropropene	8	9	0	NA	NA				
	Cyclohexane	5	5	0	NA	NA				
	Dibromochloromethane	8	9	0	NA	NA				
	Dibromomethane	3	4	0	NA	NA				
	Dichlorodifluoromethane	5	5	0	NA	NA				
	Ethylbenzene	8	9	2	24	2.3	305			
	Hexachlorobutadiene	8	9	0	NA	NA	11			
	Hexachloroethane	3	3	0	NA	NA	804			
	Isopropylbenzene	8	9	2	9	0.48	86			
	Methyl acetate	5	5	0	NA	NA				
	Methyl tert-butyl ether (MTBE)	5	5	0	NA	NA				
	Methylcyclohexane	5	5	1	0.65	0.65				
	Methylene chloride	8	9	1	1.8	1.8	159			
	Methyliodide	3	4	0	NA	NA				
	n-Butylbenzene	3	4	1	84	84				
	n-Propylbenzene	3	4	1	8.3	8.3				
	p-Isopropyltoluene	3	4	0	NA	NA				
	sec-Butylbenzene	3	4	0	NA	NA				
	Styrene	8	9	0	NA	NA	7070			
	tert-Butylbenzene	3	4	0	NA	NA				
	Tetrachloroethene (PCE)	8	9	0	NA	NA	190			
	Toluene	8	9	2	1.5	0.51	1090			
	trans-1,2-Dichloroethene	8	9	0	NA	NA	1050			
	trans-1,3-Dichloropropene	8	9	0	NA	NA				
	Trichloroethene (TCE)	8	9	0	NA	NA	8950			
	Trichlorofluoromethane	8	9	0	NA	NA				
	Vinyl acetate	3	4	0	NA	NA	13			
	Vinyl chloride	8	9	0	NA	NA	202			
	m,p-Xylenes	8	9	2	2.9	1.7				
	o-Xylene	8	9	2	5.7	3.9				
	Naphthalene	46	61	61	1700000	5.4	2100		23	

Notes:

*Carbon disulfide is a common laboratory chemical. Based on the review of existing analytical data quality, these detections are considered to be the result of laboratory cross-contamination. The results are not considered representative of site conditions.

[1] Background metals concentrations based on Puget Sound (when available) or Washington State background (Ecology 1994).

cPAHs = carcinogenic polycyclic aromatic hydrocarbons
HPAH = high molecular weight PAH
LPAH = low molecular weight PAH
NA = Not applicable, as there are no detections.
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PRG = Preliminary Remediation Goal
SVOCs = semivolatile organic compounds
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds
ug/kg = micrograms per kilogram

Table 4-1 - Summary of Species Common to the Region
Bremerton Gas Works Site
Bremerton, Washington

Common Regional Species	Potentially Use of Site (Yes/Unlikely)	Notes	Reference
Aquatic Invertebrates			
Benthic Invertebrates			
Amphipods	Yes		KiTSA 2012
Barnacles	Yes		GeoEngineers 2011; KiTSA 2012
Benthic Infaunal Community	Yes		WAC 173-204
Brittle stars	Yes		GeoEngineers 2011
Clams (multiple species)	Yes		Anchor QEA 2012; KiTSA 2012
Mussels (blue and bay)	Yes		GeoEngineers 2011; KiTSA 2012
Oysters	Yes		KiTSA 2012
Polycheate worms	Yes		GeoEngineers 2011; KiTSA 2012
Scallops	Yes		KiTSA 2012
Sand dollar larvae	Yes		
Sea cucumber	Yes		
Benthivorous Shellfish			
Octopus	Yes		KiTSA 2012
Crabs	Yes		
Marine-Dependent Birds			
Piscivorous Raptor			
Bald eagle	Yes	Monitored species (state). Nest in Sinclair Inlet.	KiTSA 2012
Osprey	Yes		
Shore Birds			
Belted kingfisher	Yes		Buchanan 2006
Ducks	Yes		
Glaucous-winged gull	Yes		KiTSA 2012
Great blue heron	Yes	Monitored species (state). There is a heron rookery along southern Sinclair Inlet (KiTSA 2012).	KiTSA 2012
Marbled murrelet	Unlikely	Threatened (NMFS). Listed marbled murrelet are unlikely to be frequently present in Dyes Inlet (Anchor QEA 2012).	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Sandpiper	Yes		Buchanan 2006
Other marine and shore birds (American coot, black oystercatcher, brant, bufflehead, canvasback, common murre, cormorants, dowitcher, dunlin, gadwall, geese, green-winged teal, goldeneye, grebe, green heron, pigeon guillemot, gull, loon, merganser, northern pintail, parasitic jaeger, plover, red-necked phalarope, rhinoceros auklet, sanderling, sand piper, scaup, scoter, surfbird, tern, turnstone, and American wigeon)	Yes		NOAA 2000; Buchanan 2006
Fish			
Benthivorous Fish			
Eelpout	Yes		NOAA 2000
Flatfish (English sole, butter sole, dover sole, sand sole, rock sole, CO sole, and starry flounder)	Yes		KiTSA 2012
Other bottomfish (skate, sablefish, greenlings, wolf-eel, Pacific sanddab, and plainfin midshipman)	Yes		NOAA 2000
Perch (pile and striped)	Yes		
Plainfin midshipman	Yes		
Poacher	Yes		
Prickleback	Yes		
Rock sole	Yes		KiTSA 2012
Spotted ratfish	Yes		
Omnivorous Fish			
Baby goby	Yes		NOAA 2000
Chum salmon	Yes	Chum are anadromous and may utilize the site for only a portion of the year.	KiTSA 2012
Coho salmon	Yes	Coho salmon are anadromous and may utilize the site for only a portion of the year.	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Cutthroat trout	Yes	Cutthroat trout are anadromous and may utilize the site for only a portion of the year.	GeoEngineers 2011; Anchor QEA 2012
Green sturgeon	Unlikely	Threatened (Southern DPS; NMFS). Unlikely to be found in Dyes Inlet (Anchor QEA 2012).	Anchor QEA 2012
Gunnel	Yes		NOAA 2000
Herring	Yes	Dyes Inlet supports a small herring stock (Anchor QEA 2012).	Anchor QEA 2012
Pink salmon	Yes	Pink salmon are anadromous and may utilize the site for only a portion of the year.	KiTSA 2012
Sockeye salmon	Yes		
Steelhead trout	Yes	Threatened (Puget Sound DPS4; NMFS). Listed Steelhead are anadromous and may utilize the site for only a portion of the year.	GeoEngineers 2011; Anchor QEA 2012
Sculpin (cabezon, Pacific stagehorn, and roughback)	Yes		NOAA 2000
Sand lance	Yes	May serve as prey to salmonids.	GeoEngineers 2011; Anchor QEA 2012
Surf smelt	Yes	May serve as prey to salmonids.	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012

Table 4-1 - Summary of Species Common to the Region

Bremerton Gas Works Site
Bremerton, Washington

Common Regional Species	Potentially Use of Site (Yes/Unlikely)	Notes	Reference
Piscivorous Fish			
Bocaccio rockfish	Unlikely	Endangered (Puget Sound/Georgia Basin DPS; NMFS). Rarely observed in Puget Sound (Anchor QEA 2012).	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Bull trout	Unlikely	Threatened (Coastal-Puget Sound DPS4; USFWS). Listed bull trout are anadromous. No bull trout stocks have been identified in any of the streams draining into the larger Sinclair Inlet basin, and no designated critical habitat is present within Kitsap County (Anchor QEA 2012).	
Canary rockfish	Unlikely	Threatened (Puget Sound/Georgia Basin DPS; NMFS). Unlikely to be present at the site due to unsuitable habitat (Anchor QEA 2012).	
Chinook salmon	Yes	Threatened (Puget Sound ESU3; NMFS). Adult Chinook are anadromous and may utilize the site for only a portion of the year.	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Ling cod	Yes		NOAA 2000
Non-listed rockfish (brown, copper, greeenstriped, yellowtail, quillback, black, and yelloweye)	Yes		
Spiny dogfish	Yes		
Yellow rockfish	Unlikely	Threatened (Puget Sound/Georgia Basin DPS; NMFS). Unlikely to be present at the site due to unsuitable habitat (Anchor QEA 2012).	GeoEngineers 2011; Anchor QEA 2012
Piscivorous Mammals and Other Marine Mammals			
Dall's porpoise	Yes	Puget Sound resident species.	KiTSA 2012
California sea lion	Yes	Seasonal species.	
Gray whale	Unlikely	Seasonal species. Has been observed in Sinclair Inlet.	
Harbor porpoise	Yes	Species of concern (state). Puget Sound resident species.	
Harbor seal	Yes	Species of concern (state). Puget Sound resident species. Harbor seals are known to be present in Dyes Inlet (Anchor QEA 2012).	
Humpback whale	Unlikely	Endangered (NMFS). Humpback whales are infrequently observed in Puget Sound (GeoEngineers 2011). Unlikely to be found in Dyes Inlet (Anchor QEA 2012).	GeoEngineers 2011; Anchor QEA 2012
Killer whale	Unlikely	Endangered (Southern Resident DPS4; NMFS). Listed Orca whales are only present in Puget Sound for a portion of the year (fall/winter). They have been infrequently observed in Dyes Inlet (Anchor QEA 2012).	Anchor QEA 2012; KiTSA 2012
Minke whale	Unlikely		KiTSA 2012
Northern sea lion	Yes	Seasonal species.	
River otter	Yes	Puget Sound resident species. Risk to species will be addressed by assessment of piscivorous mammal receptor.	
Stellar sea lion	Unlikely	Unlikely to be found in Dyes Inlet (Anchor QEA 2012). Risk to species will be addressed by assessment of piscivorous mammal receptor.	GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Macrophytes			
Algae and kelp	Yes	Aquatic vegetation in Dyes Inlet is patchy (Anchor QEA 2012). Dyes Inlet and Sinclair Inlet do not support any floating kelp (Anchor QEA 2012). Non-floating kelp species are present in just 18% of the shoreline throughout the entire basin (PSP 2005; Anchor QEA 2012). May serve as habitat and food for marine species (KiTSA 2012).	Anchor QEA 2012; KiTSA 2012
Popweed	Yes		KiTSA 2012
Sea lettuce	Yes		
Eelgrass	Unlikely	Within Dyes Inlet and Chico Bay there are scattered patches of eelgrass in intertidal areas with muddy to sandy substrates (WDNR 2001; Anchor QEA 2012). Suitable eelgrass habitat is not present at the Site.	Anchor QEA 2012; KiTSA 2012
Terrestrial Species			
Avian Predator			
Black-capped Chickadee	Yes		KiTSA 2012
Crow	Yes		
Evening grosbeak	Yes		
Flicker	Yes		
Golden-crowned kinglet	Yes		
Purple martin	Yes	Species of concern (state)	
Ring-necked pheasant	Yes		
Robin	Yes		
Starling	Yes		
Steller's jay	Yes		
Carnivorous Mammals			
Coyote	Yes		KiTSA 2012
Fox	Unlikely	Unlikely to be present at the site due to unsuitable habitat.	
Lynx	Unlikely		

Table 4-1 - Summary of Species Common to the Region

Bremerton Gas Works Site
Bremerton, Washington

Common Regional Species	Potentially Use of Site (Yes/Unlikely)	Notes	Reference
Herbivorous Mammals			
Deer	Unlikely	Unlikely to be present at the site due to unsuitable habitat.	KiTSA 2012
Rabbits	Yes		
Squirrels	Yes		
Vole	Yes		
Insectivorous Mammal			
Shrews	Yes		
Omnivorous Mammals			
Black bear	Unlikely	Unlikely to be present at the site due to unsuitable habitat.	KiTSA 2012
Mice	Yes		
Moles	Yes		
Raccoon	Yes		
Other Miscellaneous Fauna			
Garter snakes	Yes	Habitat at the site includes the upland embankment and unpaved upland site areas.	KiTSA 2012
Newts and frogs	Unlikely	Amphibians are not likely to be present at the site due unsuitable habitat.	
Salamanders	Unlikely	Amphibians are not likely to be present at the site due unsuitable habitat.	
Turtles	Unlikely	Turtles are not likely to be present at the site due to unsuitable habitat.	
Upland Vegetation			
Big leaf maple	Yes	Native vegetation. Limited in developed site areas.	KiTSA 2012
Douglas fir	Yes		GeoEngineers 2011; KiTSA 2012
Kinnikinnick	Yes		KiTSA 2012
Oregon grape	Yes		
Pacific madrone	Yes		
Pacific rhododendron	Yes		
Pacific gumweed	Yes		GeoEngineers 2011
Red alder	Yes		GeoEngineers 2011; Anchor QEA 2012
Salal	Yes		KiTSA 2012
Sword fern	Yes		
Vine maple	Yes		
Western hemlock	Yes		
Western red cedar	Yes		
Japanese knotweed	Yes	Non-native species.	Anchor QEA 2012
Himalayan blackberry	Yes		GeoEngineers 2011; Anchor QEA 2012; KiTSA 2012
Magnolia	Yes		GeoEngineers 2011
Pampas grass	Yes		
Scotch broom	Yes		GeoEngineers 2011; KiTSA 2012
Spear saltbrush	Yes		GeoEngineers 2011
Thistle	Yes		KiTSA 2012

Notes:
Underlined = Representative species included as part of ecological A31CSM figures.
Anchor QEA, 2012. *Biological Evaluation* . Chico Creek Estuary Restoration Project. January 2012.
Buchanan, J.B., 2006. *Nearshore Birds in Puget Sound* . Puget Sound Nearshore Partnership. Report number 2006-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.
DPS = distinct population segment
ESU = evolutionary significant unit
GeoEngineers, 2011. *Biological Assessment* . Bay Street Pedestrian Enhancement/Mosquito Fleet Trail Project. LSTPE-0166 (008). Port Orchard, Washington. Prepared for City of Port Orchard. August 26, 2011.
KiTSA (Kitsap Trees and Shoreline Association), 2012. Sinclair Inlet Development Concept Plan. Sponsored by KiTSA.
NMFS = National Marine Fisheries Service
NOAA (National Oceanic and Atmospheric Administration), 2000. Gustafson R.G., W.H. Lenarz, B.B. McCain, C.C. Schmitt, W.S. Grant, T.L. Builder, and R.D. Methot. 2000. Status review of Pacific Hake, Pacific Cod, and Walleye Pollock from Puget Sound, Washington. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC- 44, 275 p.
PSP (Puget Sound Partnership), 2005. Regional Nearshore and Marine Aspects of Salmon Recovery. June 2005.
USFWS = U.S. Fish and Wildlife Service

Table 4-2 - Nationwide MGP Site Summary
Bremeton Gas Works Site
Bremerton, Washington

MGP Site Name & Location	Reference	Geologic Conditions	Groundwater / Surfacewater	Chemicals of Concern	Remedial Actions	Cleanup Status
Cold Spring MGP Site Cold Spring, NY	Record of Decition (2010) http://www.dec.ny.gov/docs/remediation_hudson_pdf/e340026arod.pdf	•Subsurface soils consist of 11-13 feet of debris containing fill underlain by a 15 foot thick layer of clay, which overlies bedrock. •Contamination confined to the fill material.	•Groundwater flows to the west, towards the Hudson River which is adjacent to the site. •No contamination was observed in river sediments.	BTEX PAHs	Excavation and off-site treatment/disposal.	Scheduled to begin late 2014
Saranac Street MGP Site Plattsburgh, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/rod51000701.pdf	•Subsurface soils consist of up to 21 feet of debris containing fill underlain by up to 15 foot thick layer of sandy alluvium. Beneith the alluvium lies a layer of dense glacial till, which overlies limestone bedrock. •Contamination present down to and into fractured bedrock.	•The Saranac River forms the southern, western, and northern site boundary. •Coal tar discharged into the river along the northwestern and norther site boundaries.	BTEX PAHs	*In situ* stabilization; Soil and sediment excavation with off-site treatment/disposal; Bedrock tar collection wells.	Remedial Action complete
Waterville MFG Plant Waterville, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/633041_1.pdf	•Subsurface soils consist of one foot of topsoil over a fill unit up to 12 feet thick consisting of a substantial amount of ash as well as brown sand and gravel, coal fragments and bricks. Below the fill is a unit of glacial outwash sand and silt ranging in thickness from 1 to 10 feet. A dense kame moraine silt and gravel depcsit of depths from 4 to 12 feet was found below the outwash unit. •Contamination present up to 14 feet below grade.	•A western flowing tributary to Big Creek forms the southern edge of the property, approximately 150 feet south of the site. •The depth to groundwater ranges from approximately 4 to 12 feet below grade. Groundwater flow through the site is to the south-southwest and discharges into the Big Creek tributary.	BTEX PAHs	Excavation and Disposal; Institutional Controls; Soil Cap.	No Further Action required
Cortland Homer Former MGP Site Homer, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/rod712005.pdf	•Subsurface soils consist of a fill layer ranging from 6 inches to 10 feet and is underlain by outwash sand that varies in thickness from 20 to 40 feet. A confining silt/clay layer was observed benieth the outwash sand. •Contamination present up to 37 feet below grade.	•The West Branch of the Tioughnioga River is located 150 feet east of the site parcels. •Depth to groundwater at the site is approximately 5 feet below grade. Groundwater flow is in a east to east-southeast direction. Groundwater discharges into the river. •River sediments have been impacted by contaminants.	BTEX PAHs Cyanide	Excavation and disposal of source area soils; *In situ* stabilization of downgradient contaminated soils; NAPL collection trench; Sediment removal.	Remedial Design complete

Table 4-2 - Nationwide MGP Site Summary
Bremeton Gas Works Site
Bremerton, Washington

MGP Site Name & Location	Reference	Geologic Conditions	Groundwater / Surfacewater	Chemicals of Concern	Remedial Actions	Cleanup Status
Tacoma Tar Pits Tacoma, WA	http://yosemite.epa.gov/R10/CLEANUP.NSF/sites/TacomaTarpits/$FILE/TTP-5Yr-Review-Sept03.pdf	•Subsurface soils consist of several feet of fill underlain by a layered sequence of silts and sands.	•The Puyallup River is just norheast of the site. •Groundwater occurs several feet below ground surface at the Tacoma Tar Pits site. The groundwater levels at the site vary in response to the tidal action in Commencement Bay and adjacent waterways. Groundwater flow directions vary depending on location, season, and tide stage. In general however, groundwater typically flows east (northwest and central potions of the site) and south (southeast portion of the site).	BTEX PAHs	Excavation and stabilization; Stabilized material placed in an engineered waste pile on site; Soil cap; Groundwater pump and treat.	Ongoing O&M for cover and groundwater treatment system
Oakland MGP Oakland, CA	http://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=01490012	•Subsurface soils consisting of up to 5 feet of gravel/sand fill underlain by a sandy layer that extends up to 15 feet below grade with interbeded layers of silt and clay. The sandy layer is underlain by a fine-grained layer of clay and silt up to 20 feet below grade. •Contamination present up to 21 feet below grade.	•Groundwater is 2 to 7.5 feet bgs and flows towards the Oakland Inner Harbor, which is approximately 1000 feet away.	TPH BTEX PAHs Cyanide	Soil cap.	Ongoing O&M
Glens Falls - Mohican Street MGP Glens Falls, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/557016roda2.pdf	•Subsurface soil cosists of fill underlain by glacial fluvial deposits of sand, silt, silty sand, sandy silt. A layer of silty clay overlies bedrock, which is encountered between 9-29 feet below grade. •Contamination present up to 19 feet below grade.	•The site is bounded to the south by the Glens Falls feeder canal. •Groundwater is 2-14 feet below grad and flows towards the Glens Falls canal and Hudson River. •Canal sediments are impacted.	BTEX PAHs	Excavation of source material; Oxygen delivery system; Soil cover; Institutional controls; Dredging and disposal.	Remedial Action approved
Gastown MGP Site Tonawanda, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/rod915171text.pdf http://www.dec.ny.gov/chemical/58387.html	•Subsurface soils consist of up to 22 feet of debris containing fill underlaini by layers of sand and silt for an additional 24 feet below grade. •Contamination present down into the sand/silt layers.	•The site is bounded to the north-northwest by Tonawanda Creek. •Groundwater is approximately 6 feet below grade and flows to the north into Tonawanda Creek. •Creek sediments have been impacted.	BTEX PAHs	Excavation and disposal; *In situ* stabilization; NAPL collection wells.	Scheduled to begin in 2013
Former Sacramento MGP Sacramento, CA	http://www.pge.com/about/environment/taking-responsibility/mgp/sacramento.shtml	•Subsurface soils consist of up to 15 feet of fill underlain by a layer containing mostly silts and clayey silts to 25 feet below grade. A layer of unconolidated sand extends from approximately 25 feet to 85 feet below grade. •Contamination present up to 45 feet below grade.	•The site is located adjacent to the Sacramento River. •Groundwater is present approximately 18 feet below grade and flow is strongly incluenced by the Sacramento River and flows to the east.	TPH BTEX PAHs	Excavation and disposal; Pump and treat; *In situ* stabilization.	*In situ* stabilization implemented late 2012
Former Red Bluff MGP Red Bluff, CA	http://www.pge.com/about/environment/taking-responsibility/mgp/red-bluff.shtml	•Subsurface soil consists of up between 3 and 28 feet of debris containing fill material underlain by a sily clay / clayey silt with interbedded sand, grave, and finer-grained sediments. •Contamination present in the fill material.	•The site is bound to the east by the Sacramento River. •Groundwater is present between 4 and 39 feet below grade and is heavily influenced by river level. Groundwater flows either east, or west, depending on river stage.	TPH BTEX PAHs	Excavation and disposal of shallow source soils; *In situ* stabalization of deeper source soils.	Remedial Action approved

Table 4-2 - Nationwide MGP Site Summary
Bremeton Gas Works Site
Bremerton, Washington

MGP Site Name & Location	Reference	Geologic Conditions	Groundwater / Surfacewater	Chemicals of Concern	Remedial Actions	Cleanup Status
Georgia MGP	http://www.geiconsultants.com/stuff/contentmgr/files/0/50b92d14438556ba3621879700e41ab4/download/insitustabilization.pdf	•Subsurface soil consists of up to 22 feet of fill underlain by 15 feet of alluvium above weathered bedrock. •Contamination present to the bedrock.	The site is bounded to the west by the Chattahoochee River.	BTEX PAHs	*In situ* stabilization; Excavation and disposal; Groundwater barrier.	Remedial Action complete
Nyack MGP Site Nyack, NY	http://www.dec.ny.gov/docs/remediation_hudson_pdf/rod34404601.pdf	•Subsurface soil consists of up to 13 feet of fill underlain by native silty sand and glacial till layers. Sandstone bedrock was encountered approximately 40 feet below grade. •Contamination present to the bedrock.	•The site is bound to the north by the Hudson River. •The bedrock is a productive aquifer with the groundwater flowing upward through the bedrock. Groundwater generally flows toward the Hudson River. •River sediments have been impacted.	BTEX PAHs	Excavation and disposal; *'In situ* stabilization; *In situ* chemical oxidation; Dredging and disposal.	Upland solidification complete. Sediment removal scheduled to begin in 2013
Manitowoc Former MGP Site Manitowoc, WI	http://www.epa.gov/region05/cleanup/manitowoc/pdfs/manitowoc-completion-report-20070725.pdf	•Subsurface soil consists of 3-10 feet of miscellaneous sand/silt/clay fill material overlying glacial deposits of sind with varying amounts of gravel, silt, and clay. Unconsolidated materials extend to at least 40 feet below grand and bedrock is estimated to be approximately 48 to 50 feet below grade. •Contamination present up to 27 feet below grade.	•The site is bound to the northwest by the Manitowoc River. •Groundwater is present between 5 and 22 feet below grade and flows towards the Manitowoc River. •River sediments have been impacted.	BTEX PAHs Cyanide	Shallow excavation and disposal; *In situ* stabilization; Pump and treat (carbon); *In situ* stabilization for sediments failed; Dredging.	Pump and Treat O&M Sediment dredging scheduled to begin December 2013
Kinston MGP Site Kinston, NC	http://www.neuselibrary.org/Kinston%20MGP%20Remedial%20Action%20Plan.pdf	•Subsurface soils consist of gravel fill underlain by a fine to medium grained sand layer with some gravel and clay up to 21 feet below grade. The sandy layer is underlain by a silt/clay which extends up to 45 feet below grade, followed by a silty sand extending to 55 feet below grade. •Contamination present up to 23 feet below grade.	•The Neuse River borders more than 50% of the Site including the north, west, and southwest boundaries. •Groundwater flow is to the southwest, towards the Neuse River. •River sediments have been impacted.	BTEX PAHs Cyanide	*In situ* stabalization; Institutional controls.	Remedy selected, awaiting implementation

Notes:
BTEX = benzene, tolouene, ethylbenzene, and xylenes
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
MGP = manufactured gas plant
NAPL = non-aqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

Table 4-3 - Summary of Preliminary Contaminants of Potential Concern
Bremeton Gas Works Site
Bremerton, Washington

Preliminary Contaminants of Potential Concern		Reason for Inclusion					Potential Sources of MGP-Related Contaminants (see Note 1)									Potential Human Health and Environmental Concerns (see Note 2)		
							Feedstocks and Fuels			MGP Process Byproducts								
Contaminant Group	Contaminant	Potential MGP-Related Constituents	Other Sources (see Note 3)	Detected in Previous Sampling Efforts	Detected Above Initial PRGs	Other EPA Contaminants	Gasoline	Diesel fuel oil	Coal/coke briquettes	Ash, clinker, cinder, slag, soot, bricks	Spent scrubber media (tarry wood chips)	Tar (potentially as DNAPL)	Light oil (potentially as LNAPL)	Gas Liquor and Emulsion (tar-water mixture)	Spent purifier media (iron oxide, tarry wood chips)	Human Health Risk (Carcinogen)	Other Human Health Risks (non-Carcinogen)	Toxicity to Ecological Receptors
Volatile Organic Compounds	Benzene	X	X	X	X		X				X	X	X	X	X	X	X	X
	Toluene	X	X	X			X				X	X	X	X	X		X	X
	Ethylbenzene	X	X	X	X		X				X	X	X	X	X		X	X
	Xylenes	X	X	X	X		X				X	X	X	X	X		X	X
	1,2,3-Trichlorobenzene			X													X	
	1,2,4-Trimethylbenzene	X	X	X			X				X	X	X	X	X		X	X
	1,3,5-Trimethylbenzene			X													X	
	1,4-Dichlorobenzene			X												X	X	X
	1,4-Difluorobenzene			X														
	1,2-Dichloroethane		X	X	X											X	X	X
	2-butanone			X													X	X
	Acetone			X													X	X
	Carbon disulfide			X													X	X
	Carbon Tetrachloride		X	X	X											X	X	X
	Chlorobenzene-d5			X													X	X
	Chloroform		X	X	X											X	X	X
	cis-1,3-Dichloropropene		X	X	X											X	X	
	cis-1,2-Dichloroethene			X													X	
	Cyclochexane			X													X	
	Isopropylbenzene			X													X	X
	Methyl acetate			X													X	
	Methylcyclohexane			X														
	Methylene chloride			X												X	X	X
	n-Butylbenzene			X													X	
	n-Hexane			X	X												X	X
	n-Propylbenzene			X													X	
	Pentafluorobenzene			X														
	p-Isopropyltoluene			X														
	sec-Butylbenzene			X													X	
	Styrene			X													X	X
	Tetrachloroethene			X												X	X	X
	trans-1,3-Dichloropropene		X	X	X											X	X	
	Trichloroethene		X	X	X											X	X	X
	Trichlorofluoromethane			X													X	X
Polycyclic Aromatic Hydrocarbons	Benzo(a)anthracene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Benzo(b)fluoranthene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Benzo(k)fluoranthene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Benzo(a)pyrene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Chrysene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Dibenz(a,h)anthracene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Indeno(1,2,3-cd)pyrene	X	X	X	X				X	X	X	X		X	X	X	X	X
	Acenaphthene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Acenaphthylene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Anthracene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Benzo(g,h,i)perylene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Dibenzofuran			X	X												X	X
	Fluoranthene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Fluorene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Phenanthrene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Pyrene	X	X	X	X			X	X	X	X	X		X	X		X	X
	Methylnaphthalene, 1-	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X
	Methylnaphthalene, 2-	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X
	Naphthalene	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X

Table 4-3 - Summary of Preliminary Contaminants of Potential Concern
Bremeton Gas Works Site
Bremerton, Washington

Preliminary Contaminants of Potential Concern		Reason for Inclusion					Potential Sources of MGP-Related Contaminants (see Note 1)									Potential Human Health and Environmental Concerns (see Note 2)		
							Feedstocks and Fuels			MGP Process Byproducts								
Contaminant Group	Contaminant	Potential MGP-Related Constituents	Other Sources (see Note 3)	Detected in Previous Sampling Efforts	Detected Above Initial PRGs	Other EPA Contaminants	Gasoline	Diesel fuel oil	Coal/coke briquettes	Ash, clinker, cinder, slag, soot, bricks	Spent scrubber media (tarry wood chips)	Tar (potentially as DNAPL)	Light oil (potentially as LNAPL)	Gas Liquor and Emulsion (tar-water mixture)	Spent purifier media (iron oxide, tarry wood chips)	Human Health Risk (Carcinogen)	Other Human Health Risks (non-Carcinogen)	Toxicity to Ecological Receptors
Other Semi-volatile Organic Compounds	1,1'-Biphenyl			X												X	X	X
	1,2,4-Trichlorobenzene			X												X	X	X
	2,4-Dimethylphenol			X													X	X
	4-Methylphenol			X														X
	Acetophenone			X													X	
	Benzyl butyl phthalate			X												X	X	X
	Benzaldehyde			X													X	
	Bis(2-ethylhexyl) phthalate			X												X	X	X
	Caprolactam			X													X	
	Carbazole	X									X	X		X	X		X	X
	creosols	X									X	X		X	X		X	X
	Dibenzofuran	X									X	X		X	X		X	X
	Di-n-butyl phthalate			X													X	X
	Isophorone			X												X	X	X
	Pentachlorophenol		X	X	X											X	X	X
	Phenol	X									X	X		X	X		X	X
Metals[4]	Aluminum			X													X	X
	Antimony			X	X												X	X
	Arsenic		X	X	X											X	X	X
	Barium			X													X	X
	Beryllium			X													X	X
	Cadmium		X	X	X												X	X
	Chromium		X	X	X												X	X
	Cobalt			X	X												X	X
	Copper		X	X	X												X	X
	Iron			X													X	X
	Lead		X	X	X												X	X
	Manganese			X	X												X	X
	Mercury			X													X	X
	Nickel		X	X	X												X	X
	Selenium			X													X	X
	Silver			X													X	X
	Thallium			X	X												X	X
	Vanadium			X	X												X	X
	Zinc		X	X	X												X	X
Polychlorinated Biphenyls (PCBs)[5]						X										X	X	X
Pesticides[6]						X										X	X	X
Other	Cyanide, WAD	X													X		X	X
	Cyanide, total	X													X		X	X
	Sulfide	X																X

Notes
1) Contaminants of Potential Concern (COPCs) associated with MGP sources based on typical composition of MGP-related feedstocks and byproducts (see Section 2.3.1.1)
2) Potential Human Health and Environmental Concerns identified based on whether risk-based screening levels or potential ARARs for human health (carinogenic health effects), human health (non-carcinogenic health effects), or ecological health effects were identified during development of initial Preliminary Remediation Goals (PRGs) (see Section 6).
3) Other Sources include other historical operations at the site or regional sources of contamination
4) Although previously detected at the Site, non-toxic metals (calcium, magnesium, sodium and potassium) are not included herein. Initial PRGs were not developed for these metals because they are essential nutrients that can be tolerated in high doses by living systems.
5) PCBs were previously analyzed for and not detected above reporting limits in soil or groundwater at the Site. However, the full standard list of PCB aroclors are COPCs for further evaluatior
6) The full standard list of pesticides, identified and quantified by EPA Method 8081B, are preliminary COPCs

This table is not intended to be an exhaustive and complete preliminary list of Site COPCs. The RI/FS will include analysis of samples for the full standard list of analytes under each contaminant group. This list will be evaluated and revised as data is collected and specific contaminants can either be eliminated from the COPC list or are identified as Site COPCs.

Table 5-1 - Remedial Technologies for NAPL

Bremerton Gas Works Site
Bremerton, Washington

NAPL General Response Actions	Remedial Technology	Process Options	Description
Institutional Controls	Access Restrictions	Fences and warning signs to control Site access	Signs, fences, or other measures to prevent access to the Site.
	Use Restrictions	Use restrictions and monitoring to prevent disturbance of engineered controls	Covenant placed on property that limits or prohibits activities that may interfere with a cleanup action or result in exposure to hazardous substances. Use and deed restrictions are often used in conjunction with other technology approaches.
		Deed restrictions addressing soil disturbance and/or groundwater wells	
In Situ Containment	Vertical Barriers	Slurry Wall	Control lateral movement of NAPL by excavating a trench and backfilling with a low-permeability material (e.g., bentonite slurry), or *in situ* mixing of bentonite with native soils.
		Sheet Pile Wall	Control lateral movement of NAPL by installing (driving or vibrating) steel or plastic sheet piling.
		Grout Curtain	Control lateral movement of NAPL by pressure injecting hydraulic cements, clays, bentonite, and silicates into the formation through tightly spaced borings using jetting tools.
In Situ Treatment	Low-Temperature Thermal Treatment	Hot Water Injection	A variety of heating methods, heating to temperatures less the boiling point of water, increasing the mobility and solubility of NAPL. Contaminated liquids, including NAPL, are removed by pumping from wells, and contaminants are treated. Heating can be performed by injecting hot water in vertical wells, thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Electrical Resistance Heating	
		Thermal Conductive Heating	
	Mid-Temperature Thermal Treatment	Steam Injection	The subsurface is heated to temperatures near the boiling point of water, volatilizing or destroying (by pyrolysis) volatile organic compounds. Contaminated vapors are collected using soil vapor extraction, contaminated liquids are removed by pumping from wells, and contaminants are treated. Heating can be performed by injecting steam in vertical wells, thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Electrical Resistance Heating	
		Thermal Conductive Heating	
	High-Temperature Thermal Treatment	Electrical Resistance Heating	The subsurface is heated to temperatures above the boiling point of water, volatilizing or destroying (by pyrolysis) volatile and semi-volatile organic compounds. Contaminated vapors are collected using soil vapor extraction, contaminated liquids are removed by pumping from wells, and contaminants are treated. Heating can be performed by thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Thermal Conductive Heating	
	Stabilization	Solidification/ Stabilization	Soil containing NAPL is stabilized by adding amendments to solidify or immobilize contaminants. Potential amendments include polymers, pozzolans, and cement. Amendments can be mixed with soil *in situ* using large-diameter augers, soil mixers, or similar equipment.
	Chemical Treatment	Chemical oxidation	Chemical oxidation involves the injection of chemical oxidants into the subsurface to react with and destroy organic contaminants. Common oxidants include hydrogen peroxide, potassium permanganate, ozone, and sodium persulfate.
Removal	NAPL Pumping	Pumping of NAPL from wells and trenches	Pumping to remove NAPL that accumulates in a well or trench.
	Surfactant Enhanced Recovery	Pumping of mobilized NAPL	Surfactants are injected near NAPL zones in groundwater to mobilize the NAPL, and then the mobilized NAPL is extracted. May be applied with injection-withdrawal technique or with recirculating system.
	Excavation	Excavation	NAPL is removed by excavating soil containing NAPL.
Ex Situ Treatment	Thermal	Co-Burning	Combustion of coal tar or tar contaminated soil with coal in utility boilers and cement kilns.
		Incineration	When soil or sediment containing NAPL is heated to temperatures above 1,400°F, contaminants are directly oxidized.
Disposal	Off-Site Management	Recycling of recovered NAPL	Reuse of recovered product.
		Disposal of recovered NAPL via incineration	Treatment of NAPL via incineration at a hazardous waste treatment facility.

Notes:
BTEX = benzene, tolouene, ethylbenzene, and xylenes
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NAPL = non-aqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

Table 5-2 - Remedial Technologies for Soil

Bremerton Gas Works Site
Bremerton, Washington

Soil General Response	Remedial Technology	Process Options	Description
Institutional Controls	Access Restrictions	Fences and warning signs to control Site access	Signs, fences, or other measures to prevent access to the property.
	Use Restrictions	Use restrictions and monitoring to prevent disturbance of engineered controls	Covenant placed on the property that limits or prohibits activities that may interfere with a cleanup action or result in exposure to hazardous substances.
		Deed restrictions addressing soil disturbance	
In Situ Containment	Capping	Permeable soil cover	Placing clean soil on the surface provides a barrier that prevents exposure to underlying soil but allows storm water to infiltrate.
		Low-permeability cap	Low-permeability caps may be constructed of low-permeability soil such as clay or an engineered material such as asphalt or concrete. This cap would not only prevent exposure to underlying soils, but would also minimize stormwater infiltration through potentially contaminated materials, thereby reducing mobility of contaminants located in the unsaturated soil zone. Engineered materials could also be used in areas requiring a durable surface, such as high-traffic areas.
		Impervious cap	Impervious caps may be constructed of low-permeability soil such as clay or an engineered material such as asphalt or concrete, overlain by an additional impermeable layer. This cap would not only prevent exposure to underlying soils, but would also prevent stormwater from infiltrating through potentially contaminated soils beneath the cap, thereby reducing mobility of contaminants located in the unsaturated soil zone. Often combined with barrier wall technology to fully encapsulate soils.
In Situ Treatment	Physical Removal and Treatment	Passive venting of soil vapors	Passive soil venting is a less aggressive version of soil vapor extraction that is usually applied to prevent contaminated soil vapors from migrating into buildings or crawl spaces. In passive venting, soil vapors beneath a building foundation are vented to the atmosphere either through atmospheric pressure changes or by applying a low vacuum with a ventilation fan. Vented vapors can be passed through activated carbon for treatment if necessary.
		Soil vapor extraction	Soil vapor extraction applies a vacuum to subsurface soil to volatilize contamination and extract soil vapor. Vapor stream is treated above ground to remove contamination before discharge.
	Low-Temperature Thermal Treatment	Hot Water Injection	The subsurface is heated to temperatures less than the boiling point of water, increasing the mobility and solubility of NAPL and NAPL constituents. Contaminated liquids are removed by pumping from wells, and contaminants are treated. Heating can be performed by injecting steam in vertical wells, thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Electrical Resistance Heating	
		Thermal Conductive Heating	
	Mid-Temperature Thermal Treatment	Steam Injection	The subsurface is heated to temperatures near the boiling point of water, volatilizing or destroying (by pyrolysis) volatile organic compounds. Contaminated vapors are collected using soil vapor extraction, contaminated liquids are removed by pumping from wells, and contaminants are treated. Heating can be performed by injecting steam in vertical wells, thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Electrical Resistance Heating	
		Thermal Conductive Heating	
	High-Temperature Thermal Treatment	Thermal Conductive Heating	The subsurface is heated to temperatures above the boiling point of water, volatilizing or destroying (by pyrolysis) volatile and semi-volatile organic compounds. Contaminated vapors are collected using soil vapor extraction, contaminated liquids are removed by pumping from wells, and contaminants are treated. Heating can be performed by thermal conduction from vertical heated wells, or by electrical resistance when voltage is applied between subsurface electrodes.
		Vitrification	Soil is heated via electrical current to temperatures greater than 2,400°F, destroying contaminants and fusing soil into a glassy matrix.

Table 5-2 - Remedial Technologies for Soil

Bremerton Gas Works Site
Bremerton, Washington

Soil General Response	Remedial Technology	Process Options	Description
In Situ Treatment	Stabilization	Solidification/ Stabilization	Soil or sediment is stabilized by adding amendments to solidify or immobilize contaminants. Potential amendments include polymers, pozzolans, and cement. Amendments can be mixed with soil *in situ* using large-diameter augers, soil mixers, or similar equipment.
	Chemical Treatment	Chemical oxidation	Chemical oxidation involves the injection of chemical oxidants into the subsurface to react with and destroy organic contaminants. Common oxidants include hydrogen peroxide, potassium permanganate, ozone, and sodium persulfate, which have been shown to destroy a wide range of contaminants in soil.
	Bioremediation	Bioventing	Bioventing supplies oxygen to unsaturated soil to increase aerobic biodegradation rates and may be designed to increase the air exchange rate through the soil.
		Amendment Injection	Biodegradation of contaminants by indigenous soil microbes can be enhanced by amending soil with nutrients, moisture, and oxygen (typically provided by injecting air or solutions into wells or trenches).
Removal	Excavation	Excavation	Excavators, backhoes, and other conventional earth moving equipment are the most common equipment used to remove contaminated soil from upland areas.
Ex Situ Treatment	Physical	Solidification/ Stabilization	Amendments are added to excavated soil or sediment to immobilize and/or bind contaminants within the stabilized product. Depending on the proportion of amending agents, the end product may take on the form of a quasi-soil/concrete material that could later be used as bulk fill.
	Thermal	Co-Burning	Combustion of Manufactured Gas Plant residues, such as coal tar and tar contaminated soil, with coal in utility boilers and cement kilns.
		Thermal desorption	Low-temperature thermal desorption involves heating soils or sediments to temperatures between 200°F and 600°F until volatile and semivolatile chemicals of concern (COCs) such as benzene and naphthalene evaporate. Exhaust gases produced by the process are typically combusted.
		Incineration	When soil is heated to temperatures above 1,400°F, contaminants are directly oxidized.
	Chemical/ Physical	Particle washing	In particle washing, soil is put in contact with an aqueous solution to remove contaminants from the soil particles. The suspension is often also used to separate fine particles from coarser particles, allowing beneficial use of the coarser fraction (if sufficiently clean) at the Site.
		Solvent extraction	Solvent extraction is a variant of soil washing in which an organic solvent (rather than an aqueous solution) is put in contact with the soil to remove contaminants.
	Bioremediation	Landfarming	Microbial population potentially enhanced with nutrients, moisture, and bioaugmentation to treat contaminated soil on lined beds with tilling and irrigation.
		Biopiles	Microbial population potentially enhanced with nutrients, moisture, aeration, and bioaugmentation to treat contaminated soil in stockpiles.
		Bioreactor	Microbial population potentially enhanced with nutrients, moisture, aeration, and bioaugmentation to treat contaminated soil in enclosed reactor vessels.
Reuse	Asphalt Batching	Cold-Mix Asphalt Batching	Encapsulation of contaminant by blending residues, wet aggregate and asphalt emulsion at ambient temperature.
		Hot-Mix Asphalt Batching	Encapsulation of contaminant by blending residues, wet aggregate and asphalt emulsion at high temperature.
Disposal	Confined On-Site Disposal	Confined On-site disposal	Excavated soils exceeding applicable cleanup standards could potentially be placed on site in a specially designed upland confined disposal facility (CDF). Depending on the leachability of confined materials, the CDF could potentially include a liner and a liquid collection system to prevent leachate from contaminating groundwater.
	Off-Site Landfill Disposal	Subtitle D (Solid Waste)	Contaminated soils from the Site may be transported to an off-site, permitted disposal facility. This disposal method provides for secure, long-term containment of hazardous and non-hazardous solid wastes.
		Subtitle C (Hazardous Waste)	

Notes:
BTEX = benzene, tolouene, ethylbenzene, and xylenes
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NAPL = non-aqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

Table 5-3 - Remedial Technologies for Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Groundwater General Response Actions	Remedial Technology	Process Options	Description
Institutional Controls	Deed Restrictions	Deed restrictions to preclude drinking water use	Covenant placed on property that limits or prohibits activities that may interfere with a cleanup action or result in exposure to hazardous substances.
		Deed restrictions addressing groundwater wells	
Monitored Natural Attenuation	Monitored Natural Attenuation	Groundwater Monitoring	Provides monitoring to document the presence and effectiveness of natural processes in removing or containing Site chemicals of concern (COCs).
In Situ Containment	Vertical Barriers	Slurry Wall	Control lateral movement of contaminated groundwater by installing impermeable vertical barriers. Vertical barriers can be constructed of a variety of materials and installation techniques, including driving or vibrating steel sheet piling, excavation of a trench and backfilling with a low-permeability material (e.g., bentonite slurry), *in situ* mixing of bentonite with native soils, or pressure injecting hydraulic cement and bentonite.
		Sheet Pile Wall	
		Grout Curtain	
	Pumping	Pumping from vertical wells or trenches	Migration of contaminants dissolved in groundwater can be controlled by pumping groundwater from vertical wells or trenches, creating a capture zone within which groundwater flows toward the capture point.
	Stormwater Controls	Targeted Infiltration	A hydraulic barrier can be created by collecting and infiltrating stormwater and forming a local groundwater "mound."
		Reduced Infiltration	Hydraulic controls can reduce localized infiltration and seepage of stormwater in impacted areas along the shoreline.
In Situ Treatment	Permeable Reactive Barrier	Sorptive/Reactive Wall	A 40-foot-deep trench may be excavated in the uplands and filled with a permeable material that sorbs dissolved-phase contaminants, facilitating further biodegradation and limiting contaminant migration toward marine sediment and surface water and offshore groundwater. A shallow trench could also excavated on the beach near the shoreline, but would be impacted by brackish water and tidally-influenced groundwater gradients.
	Chemical Treatment	Chemical Oxidation	Chemical oxidation involves the injection of oxidant solutions into saturated groundwater to react with and destroy organic contaminants. Common oxidants include hydrogen peroxide, potassium permanganate, ozone, and sodium persulfate.
	Bioremediation	Amendment Injection	Injecting compounds, such as peroxides, oxygen-releasing compound, or nutrients, that enhance degradation of contaminants.
		Biosparging	Biosparging involves the injection of oxygen, and sometimes nutrients, to groundwater to enhance aerobic bioattenuation of organic compounds. For volatile contaminants, soil vapor extraction or bioventing may be concurrently applied for unsaturated soil.
Removal	Groundwater Extraction	Pumping from Vertical Wells or Trenches	Groundwater can be removed from the subsurface by pumping fluids from wells or trenches.

Table 5-3 - Remedial Technologies for Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Groundwater General Response Actions	Remedial Technology	Process Options	Description
Ex Situ Treatment	Physical/ Chemical	Adsorption	Granular activated carbon (GAC) can be used to remove organic contaminants. Contaminated groundwater is passed through a bed of GAC, and hydrophobic organic compounds in solution adsorb onto the carbon until the carbon becomes depleted or saturated. Depleted GAC may be regenerated or disposed off Site.
		Air Stripping	Contaminated groundwater and air are typically passed counter-currently through a tower, and volatile contaminants (such as benzene and, to a lesser extent, naphthalene) transfer from the water to the air. The contaminant-laden air is usually treated by activated carbon and then discharged to the atmosphere.
		Advanced Oxidation Processes	Involves adding chemicals that directly oxidize organic contaminants in water. Process options include ozonation, hydrogen peroxide (with or without catalysts such as Fenton's Reagent or ultraviolet light), and permanganate.
	Biological	Biotreatment	Contaminated groundwater is passed through a biological reactor in which a contaminant-degrading microbial culture is maintained, generally by adding nutrients and oxygen and controlling temperature, pH, and other parameters. Process options include bioslurry reactors, fixed-film bioreactors, and constructed wetlands.
Disposal	Off-Site Management	Discharge to Sanitary Sewer	Groundwater is discharged to the local sanitary sewer system. Pre-treatment of groundwater may not be required if concentrations of chemicals of concern (COCs) meet discharge criteria. Water containing high concentrations of solids (e.g., from construction dewatering) would likely need to be passed through a settling tank or filter to meet discharge requirements.
		Discharge to Surface Water	Extracted groundwater may also be discharged to surface water, although this discharge option would likely require a National Pollutant Discharge Elimination System (NPDES) permit. Water discharged to surface water would have to meet strict water quality requirements and would likely require treatment before discharge.
	On-Site Management	Re-introduction to Groundwater	Extracted groundwater may also be discharged on site to groundwater via infiltration galleries or injection wells. Contaminated groundwater would likely require treatment before discharge via this method.

Notes:
BTEX = benzene, tolouene, ethylbenzene, and xylenes
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NAPL = non-aqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

Table 5-4 - Remedial Technologies forSediment

Bremerton Gas Works Site
Bremerton, Washington

Sediment General Response Actions	Remedial Technology	Process Options	Description
Institutional Controls	Use Restrictions	Governmental advisories and public outreach on fish/shellfish consumption	Institutional controls are measures undertaken to limit or prohibit activities that may interfere with a cleanup action or result in exposure to hazardous substances.
		Easements or restrictive covenants to limit activities which may damage the remedy or increase the potential for exposure	
		Monitoring and notification of waterway users to restrict specific activities to protect the remedy	
Monitored Natural Recovery	Monitored Natural Recovery	Monitored Natural Recovery	A passive remedial approach which relies on monitoring of ongoing, natural processes (physical, biological, and/or chemical mechanisms) that act together to reduce the risk (bioavailability and/or toxicity) of the Site COCs. Monitoring is required to evaluate the effectiveness and frequently includes multiple lines of evidence.
	Enhanced Natural Recovery	Thin-Layer Sand Placement	Thin-layer placement normally accelerates natural recovery by adding a layer of clean sediment over contaminated sediment. The acceleration can occur through several processes, including increased dilution through bioturbation of clean sediment mixed with underlying contaminants. Thin-layer placement is typically different than the *in situ* isolation caps, because it is not designed to provide long-term isolation of contaminants from benthic organisms.
In Situ Containment	Capping (Non-reactive)	Engineered Sand Cap	An engineered sand cap consists of a layer of granular material placed over contaminated sediments to contain and isolate them from the biologically active surface zone. Engineered caps may also include erosion protection or stability layers such as geosynthetics or armoring materials.
		Post-Dredge Residuals Management Layer	Similar to cap placement methods described above, with the exception that granular material is applied after dredging to manage residual contamination resulting from dredging. In some cases, a reactive media may be included in the residuals/backfill layer.
In Situ Treatment	Physical/ Chemical	Permeable Reactive Cap	A permeable reactive cap includes a reactive material (such as organoclay, coke, coal, or activated carbon) and similar to a sand cap is placed over contaminated sediments to isolate and contain the contaminated sediments. The reactive material also provides treatment by sorping or binding COCs (dissolved and/or NAPL) and further limiting migration into overlying sediment porewater and surface water.
		Stabilization	This technology involves adding amendments to in situ sediment that immobilize and/or bind contaminants within the stabilized media.
	Bioremediation	Amendment Injection	Biodegradation of contaminants by indigenous soil microbes can be enhanced by amending soil with nutrients, moisture, and oxygen (typically provided by injecting into wells or trenches).
Removal	Dredging	Hydraulic	Dredging is the removal of sediment in the wet and is primarily accomplished with hydraulic or mechanical equipment. Hydraulic dredging removes and transports sediment with entrained water in a slurry. Mechanical dredging uses mechanical equipment/force to dislodge and excavate sediment in the wet. Dredging effectiveness may be limited by resuspension, release of COCs (i.e., dissolved, particles, and sheens) to water and volatilization to air during dredging, and residual COCs remaining after dredging (USACE 2008). These effects may be reduced by use of containment (e.g., sheet pile, silt curtains) and best management practices.
		Mechanical	

Table 5-4 - Remedial Technologies forSediment

Bremerton Gas Works Site
Bremerton, Washington

Sediment General Response Actions	Remedial Technology	Process Options	Description
Ex Situ Treatment	Physical	Physical Separation	The volume of excavated or dredged contaminated materials may be reduced by physically separating the materials into two or more fractions that can be handled separately.
		Stabilization	This technology involves adding amendments to excavated sediment that immobilize and/or bind contaminants within the stabilized media.
	Thermal	Thermal Desorption	Low-temperature thermal desorption involves heating soils or sediments to temperatures between 200°F and 600°F until volatile and semivolatile COCs such as benzene and naphthalene evaporate. Exhaust gases produced by the process are typically combusted.
		Incineration	When sediment is heated to temperatures above 1,400°F, contaminants are directly oxidized.
Disposal	On-Site Beneficial Use	Sand/Aggregate Reclamation	Dredged material with high sand contents that undergo particle separation may be available for use as concrete aggregate or general upland fill.
		Topsoil Feedstock	Dredged material may be used as non-organic feedstock for topsoil (i.e., material would be blended with organics).
	Confined On-Site Disposal	Confined On-site Disposal	Removed sediments exceeding applicable cleanup standards could potentially be placed on Site in a specially designed upland CDF. Depending on the leachability of confined materials, the CDF could potentially include a liner and a liquid collection system to prevent leachate from contaminating groundwater.
		Near-shore Confined Disposal Facility (CDF)	Removed sediments exceeding applicable cleanup standards could potentially be placed on Site in a specially designed CDF built along the shoreline. Construction would require significant filling and conversion of aquatic lands.
		Contained Aquatic Disposal (CAD)	Dredged sediments may be consolidated and disposed of in a deep aquatic excavation adjacent to the Site and capped with clean material.
	Off-Site Landfill Disposal	Subtitle D (Solid Waste)	Contaminated sediments from the Site may be transported to an off-Site, permitted disposal facility. This disposal method provides for secure, long-term containment of hazardous and non-hazardous solid wastes.
		Subtitle C (Hazardous Waste)	

Notes:
BTEX = benzene, tolouene, ethylbenzene, and xylenes
COCs = chemicals of concern
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
NAPL = non-aqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons
TPH = total petroleum hydrocarbons

References: U.S. Army Corps of Engineers (USACE), 2008, Technical Guidelines for Environmental Dredging of Contaminated Sediments, ERDC/EL TR-08-29, September 2008.

Table 6-1 - Summary of Existing Information and Data Gaps - Uplands

Bremerton Gas Works Site
Bremerton, Washington

Remdial Investigation/Feasbility Study Information Needs by Topic	Existing Information	Data Gaps	Recommended Data Collection
Physical Characteristics			
Characteristics of water-bearing zones	Soil stratigraphy and observed/measured groundwater occurrence from previous investigations identifies a water-bearing zone in clean to silty glacial sands at depths of 15 to 41 feet below surface.	• Measured/tested physical properties of soil comprising water-bearing zones and aquitards. • Hydraulic conductivity of water-bearing zones and aquitards. • Vertical extent of the shallow water-bearing zone • Presence, location and nature of aquitards. • Presence, location and nature of deeper water-bearing zones.	• Soil borings to evaluate soil stratigraphy and identify water-bearing zones and aquitards. • Soil samples from borings for laboratory measurement of physical parameters that may include grain size, porosity, bulk density, and total/fraction organic carbon. • Slug tests at select site wells to measure hydraulic conductivity in each saturated stratigraphic horizon and in different water-bearing zones (if applicable).
Groundwater flow direction and gradient	Manual groundwater level measurements collected at eight wells in 2007 were used to evaluate groundwater flow direction and gradient.	• Groundwater flow direction and horizontal/vertical gradients. • Seasonal variability in water levels and groundwater gradients. • Influence of precipitation/surface water infiltration on groundwater levels. • Influence of tidal fluctuation on groundwater levels.	• Continuous water levels at site wells and in the Narrows using pressure transducers. • Precipitation amounts recorded at area weather stations.
Groundwater geochemistry	None.	• Location of salt water intrusion and extent of groundwater-surface water interaction.	• Groundwater samples will be collected from site wells for field measurements and laboratory analysis of conventional geochemical parameters, salinity.
Nature and Extent of Contamination			
Identify and evaluate source areas	Historical review of Gas Works operations identifies potential source areas.	• Identified potential source areas have not been sufficiently investigated. • Potential locations of some potential sources (e.g., tar pits, transfer piping) are unknown or roughly estimated.	• Ground-penetrating radar to identify potential subsurface features. • Advance soil borings and/or complete test pits in and around potential source areas including former process and residuals management areas, including the tar pit, residue citern, tar wells and in the ravine fill area. • Visually observe and record soil stratigraphy and indications of contamination.
Evaluate COPCs to determine COCs	Surface and subsurface soil and groundwater samples collected in 2007 and 2008 were analyzed for metals, petroleum hydrocarbons, SVOCs, VOCs and PCBs.	• Presence of COPCs previously not evaluated (e.g., cyanide).	• Soil and groundwater samples will be collected for chemical analysis of COPCs to refine COC list.
Define nature and extent of COCs in soil	Soil samples collected in 2007 and 2008 identified concentrations of metals, PAHs, and VOCs exceeding PRGs.	• Current nature and extent of COCs in soil. • Presence, nature and extent of COPCs previously not evaluated.	• Soil samples will be collected from soil borings and test pits in source areas and surrounding the Site to establish horizontal and vertical limits to the extent of comtamination. Soils will be submitted for chemical analysis of COCs.

Remdial Investigation/Feasbility Study Information Needs by Topic	Existing Information	Data Gaps	Recommended Data Collection
Define nature and extent of COCs in groundwater	Groundwater samples collected in 2007 and 2008 identified concentrations of metals, SVOCs, and VOCs exceeding PRGs.	• Current nature and extent of COCs in groundwater • Seasonal variability of COCs in groundwater.	• Groundwater samples may be collected from soil borings if encountered to evaluate presence of COCs and inform well placement. • Install monitoring wells to evaluate impacts in source areas and establish horizontal and vertical limits to the extent of contamination. Groundwater samples will be collected from monitoring wells for chemical analysis of COCs.
Define nature and extent of NAPL	Previous investigations have indicated that NAPL may be present.	• Presence/absence of NAPL • Chemical composition of NAPL • Lateral and vertical boundaries of NAPL occurences	• Advance soil borings and /or complete test pits in former Gas Works operations and residuals management areas, including the tar pit, residue cistern, tar wells, and in the ravine fill area. Visually observe and record soil stratigraphy and NAPL occurrences. • Include monitoring wells screened appropriately to monitor LNAPL (across water table) and DNAPL (above aquitards). Monitor wells for LNAPLs and DNAPL presence. • Submit representative soil samples and/or NAPL collected from soil borings, test pits, or wells for chemical analysis to characterize NAPL chemistry. • If NAPL is identified to be present: advance additional soil borings for deeper NAPL occurences and test pits for shallow NAPL occurences in areas requiring more precise definition of NAPL occurrences.
Evaluate potential for recontamination from other area sites	Soil and groundwater samples have been collected from borings and wells located upgradient of the Gas Works property show potential impacts in groundwater south of the property. Limited available data do not show impacts from bulk fuel facilities east of Pennsylvania Avenue or west of Thompson Drive extending onto the Gas Works Property.	• Potential impact from adjacent bulk fuel facilities and upgradient industrial sites.	• Soil and groundwater data collected from soil borings, test pits and monitoring wells upgradient of the former Gas Works property will be compared to evaluate the extent of contaminants exceeding screening criteria that are associated with the Gas Works site and potential contributions from other area contaminant sources.
Contaminant Fate and Transport			
NAPL migration pathways	NAPL may be present in the subsurface. MGP-related products include both LNAPL and DNAPL.	• Nature and extent of NAPL (see above) • NAPL mobility, including NAPL physical characteristics and soil lithology/physical properties	• Characterize soil characteristics, NAPL characteristics and extent (see above). • Recovery testing to evaluate potential mobility, if NAPL observed in monitoring wells.
Soil-to-groundwater pathway	Concentrations of Gas Works-associated constituents have been detected above soil and groundwater PRGs.	• Leaching potential from contaminated soils.	• Include TOC in soil testing program. • Collect groundwater chemistry data along groundwater flowpaths.

Table 6-1 - Summary of Existing Information and Data Gaps - Uplands
Bremerton Gas Works Site
Bremerton, Washington

Remdial Investigation/Feasbility Study Information Needs by Topic	Existing Information	Data Gaps	Recommended Data Collection
Soil-to-surface water pathway	Concentrations of Gas Works-associated constituents have been detected above soil PRGs.	• Discharge of contamination through stormwater runoff.	• Characterize contamination in surface soil and surface water near outfalls.
Groundwater-to-surface water pathway	Concentrations of Gas Works-associated constituents have been detected in groundwater above surface water PRGs.	• Groundwater transport parameters (velocity, pathway). • Attenuation parameters.	• Include natural attenuation parameters in groundwater testing program. • Characterize hydrogeology and chemical nature and extent (see above). Data may be incorporated into hydrogeologic and fate and transport models. • Groundwater monitoring program to assess seasonal variability and long-term trends.
Soil-to-air and groundwater-to-air pathway	Concentrations of Gas Works-associated constituents have been detected above current soil and groundwater PRGs.	• Potential impacts to future indoor air.	• Soil and groundwater data to be used with vapor transport modeling.
Human Health and Ecological Risk Assessment			
Assess potential receptors and exposure pathways	Concentrations of Gas Works-associated constituents have been detected above current soil and groundwater criteria.	• Potential risk to human health through direct contact with soil, ingestion of groundwater, and inhalation via vapor intrusion. • Potential risk to ecological receptors through direct contact with soil.	• Soil and groundwater chemical analytical results will be compared to human health and ecological risk-based criteria.

Notes:
BTEX = benzene, toluene, ethylbenzene and xylenes
COC = chemical of concern
COPC = chemical of potential concern
Cs-137 = Cesium 137 isotope
CSL = Cleanup Screening Level
CSO = combined sewer overflow
LNAPL = light non-aqueous phase liquide
MGP = manufactured gas plant
NAPL = non-aqueous phase liquid
NOAA: National Oceanic and Atmospheric Administration
PAHs = Polycyclic aromatic hydrocarbons
PRG = preliminary remediation goal
SCO = Sediment Cleanup Objective
SMS = Washington Sediment Management Standards regulations (WAC-173-204)
TOC = total organic carbon
VOC = volatile organic compound

Table 6-2 - Summary of Existing Information and Data Gaps - Sediments

Bremerton Gas Works Site
Bremerton, Washington

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Nature and Extent of Contamination			
Assess presence of chemical contaminants associated with historical MGP operations	• MGP operational history is well documented. • MGP-associated contaminants typically include PAH compounds, selected VOCs (i.e., BTEX compounds), cyanide, and dibenzofuran. • Surface sediment PAH concentrations within the intertidal beach areas have been extensively sampled. • Some testing for other parameters (semivolatiles, metals, and VOCs) has also been performed on a more limited basis.	• Sampling has not yet been performed in areas offshore of the former MGP dock. • Testing has not been performed for cyanide in sediments. • Testing for alkylated PAHs has not been performed (these parameters are useful in discriminating PAH sources in sediments).	• Collect surface sediment samples from MGP dock area. • Analyze sediment samples in selected areas for cyanide. • Analyze sediments samples in selected areas for alkylated PAH to document the "fingerprint" of MGP-associated PAH.
Identify chemical contaminants potentially associated with other historical activities within the Site	• Other potentially significant uses of the Site and vicinity include ravine fill, oil handling, CSO/stormwater discharges, adjacent marina operations, and miscellaneous industrial operations on the Sesko and McConkey properties. • Some testing for other parameters besides PAH compounds (semivolatiles, metals, and VOCs) has been performed on a limited basis.	• Sampling near non-MGP sources is not sufficient to finalize list of Site-associated contaminants. • Testing has not yet been performed offshore of former Sesko Oil dock. • Testing for alkylated PAHs has not been performed (these parameters are useful in discriminating PAH sources in sediments).	• Collect surface sediment samples from former Sesko dock area. • Analyze sediment samples in selected areas for additional parameters to finalize list of Site-associated COCs. • Analyze sediment samples in selected areas for alkylated PAH to evaluate "fingerprint" and potential presence of non-MGP sources within the Site.
Define the lateral extent of Site-associated COCs in surface sediment, including the boundary between Site-associated contamination and contamination from regional inputs	• Surface sediment PAH concentrations within the intertidal beach areas have been extensively sampled. • Some testing for other parameters (semivolatiles, metals, and VOCs) has also been performed on a more limited basis. • Extensive data are available documenting regional sediment quality within Port Washington Narrows and Dyes Inlet. Those data indicate an elevated regional PAH concentrations and the presence of certain other regional contaminants.	• The lateral extent of Site-associated PAH contamination has not been determined within Port Washington Narrows. • Given the presence of elevated PAH concentrations in regional sediments, additional sampling and "fingerprint" data will be needed to define the boundary between Site-associated PAH contamination and PAH contamination from regional inputs. • If other Site-associated COCs are confirmed, then the lateral extent of these COCs in surface sediments will need to be determined, including the boundary between Site-associated contamination and contamination from regional inputs.	• Collect surface sediment samples from across the initial study area and analyze for selected parameters. • Conduct sampling within the near-field and far-field study areas of Port Washington Narrows to evaluate regional influences on sediment quality and the boundary between Site-associated and regional contaminant sources.
Define the vertical extent of Site-associated COCs in sub-surface sediment, including the potential presence of subsurface hydrocarbon deposits (i.e., sheen or NAPL)	• Limited subsurface testing has been performed in the western portion of the intertidal beach to evaluate the vertical extent of PAH contamination and hydrocarbon sheen in that area. Results demonstrated that sediment contamination levels decreased rapidly with depth, and the area containing subsurface hydrocarbon sheen was very limited.	• Subsurface testing has not been performed in other areas of the beach. The depth of contamination is therefore not defined in those areas. • No surface or subsurface testing has been performed in areas offshore of the former MGP dock. • Core sampling data are not yet sufficient to assess whether subsurface hydrocarbon deposits (sheen or NAPL) may be present in subsurface sediments other than in the western beach area.	• Conduct sediment core sampling and chemical analysis within the initial study area to assess the vertical extent of PAH contamination. • Include sufficient core sampling locations in nearshore and offshore areas to assess the potential presence of subsurface hydrocarbon deposits (sheen or NAPL).

Table 6-2 - Summary of Existing Information and Data Gaps - Sediments
Bremerton Gas Works Site
Bremerton, Washington

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Human Health and Ecological Risk Assessment			
Assess the site-specific partitioning behavior of PAHs in sediments	• Literature data can be used to estimate potential partitioning of PAH compounds between sediment and porewater. However, these methods may not capture site-specific factors.	• No site-specific porewater testing has been performed to assess PAH partitioning behavior in sediments.	• Conduct paired analysis of bulk sediment and pore-water PAH concentrations in selected study areas for analysis of site-specific partitioning behavior.
Assess potential impacts of Site-associated COCs to benthic receptors	• The potential for benthic impacts can be assessed using bulk sediment chemistry (to be defined as described above) along with toxicity threshold values such as the SMS SCO and CSL values and/or the EPA narcosis toxicity model. • Porewater PAH data may be used directly to assess potential benthic toxicity using the EPA narcosis toxicity model.	• Site-specific bioassay testing could be used alongside bulk sediment chemistry and porewater testing data to assess potential benthic impacts. • The need for bioassay testing can be assessed after review of bulk sediment chemistry and porewater PAH data to be collected as described above.	• Contingent activity: If applicable, based on review of bulk sediment chemistry and porewater testing data, collect sediment samples from selected areas for confirmational bioassay testing. This testing could be used to verify predicted impacts and refine the lateral extent of those impacts.
Assess potential for Site-associated sediment contaminants to accumulate in the tissues of aquatic organisms	• Literature data can be used to estimate potential uptake of PAH or other contaminants in the tissues of aquatic organisms. Reliance on literature data may not capture site-specific factors.	• No site-specific tissue testing data or bioaccumulation testing data has been performed.	• Develop estimates of tissue concentrations based on bulk sediment and pore-water testing data and literature-based biota-sediment accumulation factors. • Contingent activity: If warranted, use tissue testing (preferred) or laboratory bioaccumulation testing (alternate) to directly assess the potential accumulation of site-associated COCs in selected aquatic organisms.
Document the types and quantities of aquatic species present in the vicinity of the Site and potentially relevant to human health and/or ecological risk evaluations	• Previous habitat and fish/shellfish resource surveys have been performed in the Port Washington Narrows and Dyes inlet areas, documenting locally-abundant fish and shellfish species. • Information regarding current and proposed shellfish growing areas and historical patterns of fishing and shellfish harvesting are available through state and tribal agencies. • Patterns of tribal seafood consumption have been identified in previous surveys of the Suquamish, Tulalip, and Squaxin nations.	• Additional information is required to document the habitat conditions and the types of seafood species present within Port Washington Narrows near the Site. • The sustainable shellfish yield for the Site has not been defined. Such information will be helpful in applying shellfish consumption rates documented in the EPA Region 10 Tribal Framework for Selecting Fish and Shellfish Consumption Rates to the baseline risk assessment.	• Conduct surveys of aquatic habitat and fish/shellfish resources at and near the Site within Port Washington Narrows. • Define the potential shellfish yield for the Site based on surveys of similar properties within the Port Washington Narrows area.
Evaluate potential Site-associated water quality impacts as necessary to support exposure assessments in the human health and ecological risk assessments	• No surface water data are currently available for the Site. • Regional studies have documented anthropogenic surface water contaminant inputs to Port Washington Narrows and Dyes Inlet, including, but not limited to, stormwater and CSO discharges. Any Site-specific sampling of surface water quality will need to consider potential off-site sources for measured water quality parameters.	• Surface water quality for the Site and vicinity are not currently available as required to support the risk assessment data needs.	• Analyze surface water samples for site-associated COCs. Samples to be collected from both within the initial study area and at selected background stations within Port Washington Narrows east and west of the Site.

Table 6-2 - Summary of Existing Information and Data Gaps - Sediments

Bremerton Gas Works Site
Bremerton, Washington

RI/FS Information Needs by Topic (What We Need to Know)	Existing Information (What We Already Know)	Data Gaps (What We Don't Know)	Recommended Data Collection (RI Work to Fill Data Gaps)
Sediment Stability and Recovery Processes			
Assess potential near-bottom currents on long-term sediment stability within the Site and immediate vicinity	• Peak tidal currents within Port Washington Narrows are understood from existing studies (e.g., NOAA tide and current data). • Sediment texture and particle size will be defined during surface sediment testing as described above.	• Near-bottom tidal currents can be significantly different than open-water, mid-channel currents due to local and edge effects. No near-bottom current data is available for the Site or vicinity.	• Conduct empirical measurements of near-bottom and mid-channel tidal currents for use in an analysis of sediment stability.
Quantify sedimentation rates using geochronology cores and radio-dating	• Geochronology studies have been performed in several areas of Puget Sound, documenting a general pattern of sedimentation.	• Sedimentation rates can vary with location. No sedimentation rate data are available for Port Washington Narrows areas near the Site.	• Contingent Activity: If warranted, quantify net sedimentation rates near the Site using geochronology test methods (i.e., thin-section cores analyzed with Cs-137 radio-dating).

Notes:

BTEX = Benzene, toluene, ethylbenzene, and xylenes
COC = Contaminant of Concern
Cs-137 = Cesium 137 isotope
CSL = Cleanup Screening Level
CSO = combined sewer overflow
EPA = U.S. Environmental Protection Agency
MGP = manufactured gas plant
NAPL = nonaqueous product layer
NOAA = National Oceanic and Atmospheric Administration
PAH = polynuclear aromatic hydrocarbon
RI/FS = Remedial Investigation/Feasibility Study
SCO = Sediment Cleanup Objective
SMS = Washington Sediment Management Standards regulations (WAC-173-204)
VOC = volatile organic compound

Table 6-3 - Summary of Risk Assessment Activities for Human Health

Bremerton Gas Works Site
Bremerton, Washington

Planned Risk Assessment Activities					Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters [1]	Contingent Testing[2]
Subsistence consumer of fish/crab	Dietary TDI will be estimated from dietary consumption of fish and crab, incidental sediment, and surface water. TDI estimates will be developed using EPA tribal framework. Finfish to include finfish tissue from relevant species from Suquamish Group D (halibut, sole, flounder, and rockfish).	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water. Bulk sediment data will be used along with applicable BSAFs to estimate chemical concentrations in fish and crab tissue.	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Applicable toxicity and exposure parameters	Collection of site-specific tissue samples may be proposed as an alternative to use of literature-derived BSAFs.
Subsistence consumer of shellfish [4]	TDI will be estimated from dietary consumption of shellfish (i.e., clams), incidental sediment, and surface water. TDI estimates will be developed using EPA tribal framework.	Concentrations of chemicals in intertidal surface sediment and surface water. Bulk sediment data will be used along with applicable BSAFs to estimate chemical concentrations in shellfish tissue.	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Applicable toxicity and exposure parameters	Collection of site-specific tissue samples may be proposed as an alternative to use of literature-derived BSAFs.
Recreational beach user	TDI will be estimated from dermal contact and incidental ingestion of sediment and surface water.	Concentrations of chemicals in intertidal surface sediment and surface water.	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • TDI calculation inputs • Applicable toxicity and exposure parameters	None anticipated
Construction/excavation worker in beach areas	TDI will be estimated from dermal contact and incidental ingestion of sediment. Exposure from inhalation of fugitive dust/vapor will be estimated using EPA inhalation dosimetry methodology.	Concentrations of chemicals in intertidal surface and subsurface sediment (0-6 feet below mud-line) and surface water.	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • TDI calculation inputs • Applicable toxicity and exposure parameters	None anticipated
Construction/excavation worker in upland site areas[5]	TDI will be estimated from dermal contact and incidental ingestion of soil. Exposure from inhalation of fugitive dust/vapor will be estimated using EPA inhalation dosimetry methodology.	Concentrations of chemicals in site surface and subsurface soils (0-6 feet below ground surface) and soil vapor (as estimated from soil, groundwater, or vapor data).	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • TDI calculation inputs • Applicable toxicity and exposure parameters	None anticipated

Table 6-3 - Summary of Risk Assessment Activities for Human Health

Bremerton Gas Works Site
Bremerton, Washington

Planned Risk Assessment Activities					Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters [1]	Contingent Testing[2]
On-site occupational worker[5]	TDI will be estimated from dermal contact and incidental ingestion of soil. Exposure from inhalation of fugitive dust/vapor will be estimated using EPA inhalation dosimetry methodology	Concentrations of chemicals in upland surficial soils (0-3 feet below ground surface) and soil vapor (as estimated from soil, groundwater, or vapor data).	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • TDI calculation inputs • Applicable toxicity and exposure parameters	None anticipated
Future on-site resident[5,6]	TDI will be estimated from dermal contact and incidental ingestion of soil. Exposure from inhalation of fugitive dust/vapor will be estimated using EPA inhalation dosimetry methodology. TDI from consumption of groundwater will be considered pending further evaluation of groundwater beneficial uses.	Concentrations of chemicals in upland soils (0-6 feet below ground surface), groundwater, and soil vapor (as estimated from soil, groundwater, or vapor data).	ELCR or health HQ [3]	ELCR greater than 1 in 1,000,000 or HQ greater than 1 indicates a chemical of potential concern. [3]	• Specific data to be used in evaluation • TDI calculation inputs • Applicable toxicity and exposure parameters	None anticipated

Notes:
1. The risk assessment technical memorandum will present the toxicity data and risk estimation inputs to be used, and will highlight any proposed adjustments to EPA-defined default parameters.
2. If applicable, the Risk Assessment Technical Memorandum will define supplemental data collection to be used to refine risk estimates. If contingent testing is proposed, the detailed testing plan will be documented in a Sampling and Quality Assurance Plan amendment.
3. A hazard index will be used to sum HQs for different chemicals with potentially additive effects (i.e., similar toxicological mode of action).
4. Shellfish consumption within Port Washington Narrows is currently subject to harvest restrictions. This evaluation will be performed to evaluate site-related risks associated with future harvesting activities should such restrictions be lifted.
5. No water supply wells are located on or near the Former Gas Works property and is not relevant for the construction worker or occupational worker scenario. Consumption of groundwater will be retained as a potential pathway for screening under the future on-site residential scenario, pending further evaluation of groundwater beneficial uses.
6. The site and vicinity are zoned for industrial uses, and residential use is not applicable to current or reasonably foreseeable uses. However, the risks associated with potential future on-site residential use will be evaluated to understand potential risks, should alternative site uses occur in the future.

Table 6-4 - Summary of Risk Assessment Activities for Terrestrial Receptors

Bremerton Gas Works Site
Bremerton, Washington

	Planned Risk Assessment Activities				Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	**Estimation Framework(s) for Exposure Pathway**	**Relevant RI Data to be Used (media and measurements)**	**Endpoint**	**Interpretative Framework**	**Detailed Risk Characterization Parameters [1]**	**Contingent Testing[2]**
Avian predator (e.g., robin)	Soil chemical concentrations will be compared to EPA Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of terrestrial bird populations.	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	TDI will be estimated from consumption of soil invertebrates and incidental ingestion of soil. Invertebrate tissue concentrations estimated using soil-to-tissue regression models.			HQ comparing estimated exposures from TDI to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated
Carnivore (e.g., coyote)	Soil chemical concentrations will be compared to EPA Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations.	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	TDI will be estimated from consumption of soil invertebrates, small mammals and incidental consumption of soil. Tissue concentrations will be estimated using soil-to-tissue regression models.			HQ comparing estimated exposures from TDI to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated
Omnivore (e.g., raccoon)	Soil chemical concentrations will be compared to EPA ecological soil screening levels (Eco SSL) and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	TDI will be estimated from consumption of plants, invertebrates, and incidental ingestion of soil. Plant and invertebrate tissue concentrations estimated using soil-to-tissue regression models.			HQ comparing estimated exposures from TDI to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated

Table 6-4 - Summary of Risk Assessment Activities for Terrestrial Receptors

Bremerton Gas Works Site
Bremerton, Washington

	Planned Risk Assessment Activities				Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters [1]	Contingent Testing[2]
Herbivore (e.g., vole)	Soil chemical concentrations will be compared to Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	TDI will be estimated from consumption of plants and incidental ingestion of soil. Plant tissue concentrations estimated using soil-to-tissue regression models.			HQ comparing estimated exposures from TDI to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated
Insectivore (e.g., shrew)	Soil chemical concentrations will be compared to Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	TDI will be estimated from consumption of invertebrates and incidental ingestion of soil. Invertebrate tissue concentrations estimated using soil-to-tissue regression models.			HQ comparing estimated exposures from TDI to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated
Soil invertebrate	Soil chemical concentrations will be compared to Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction of soil invertebrate communities.	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated
	Invertebrate tissue concentrations will be estimated using soil-to-tissue regression models.			HQ comparing estimated tissue concentrations to TRV based on no-effects and low-effects concentrations. [3]	• Specific data to be used in evaluation • Toxicity reference values • Applicable exposure parameters	None anticipated

Table 6-4 - Summary of Risk Assessment Activities for Terrestrial Receptors

Bremerton Gas Works Site
Bremerton, Washington

	Planned Risk Assessment Activities				Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	**Estimation Framework(s) for Exposure Pathway**	**Relevant RI Data to be Used (media and measurements)**	**Endpoint**	**Interpretative Framework**	**Detailed Risk Characterization Parameters [1]**	**Contingent Testing[2]**
Upland vegetation	Soil concentrations will be compared to Eco SSL and other relevant interpretative benchmarks (e.g., ORNL soil screening benchmarks).	Chemical concentrations in upland surface soils (0-6 feet) from vegetated areas including the upland embankment and unpaved upland site areas.	Probability of reduced survival, growth, and reproduction plant communities.	HQ comparing upper bound soil concentration to screening levels.	• Specific data to be used in evaluation • Soil screening levels and/or benchmarks • Applicable exposure parameters	None anticipated

Notes:
1. The risk assessment technical memorandum will present the toxicity data and risk estimation inputs to be used, and will highlight any proposed adjustments to EPA-defined default parameters.
2. If applicable, the Risk Assessment Technical Memorandum will define supplemental data collection to be used to refine risk estimates. If contingent testing is proposed, the detailed testing plan will be documented in a Sampling and Quality Assurance Plan amendment.
3. A hazard index will be used to sum HQs for different chemicals with potentially additive effects (i.e., similar toxicological mode of action).

Eco SSL = ecological soil screening levels
HQ = hazard quotient
ORNL = Oak Ridge National Laboratory

Table 6-5 - Summary of Risk Assessment Activities for Aquatic Receptors

Bremerton Gas Works Site
Bremerton, Washington

Planned Risk Assessment Activities					Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters[1]	Contingent Testing[2]
Piscivorous mammal (e.g., harbor seal)	Dietary TDI will be estimated from consumption of fish and invertebrates.	Concentrations of chemicals in surface sediment (intertidal and subtidal). Bulk sediment data will be used along with applicable BSAFs to estimate chemical concentrations in fish and invertebrate tissue.	Probability of reduced survival, growth, and reproduction of piscivorous mammal populations.	HQ is ratio of TDI to weight-adjusted mammalian TRV based on low- and no-effects concentrations. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples of prey species may be proposed as an alternative to use of literature-derived BSAFs for estimation of dietary TDI.
Piscivorous raptor (e.g., osprey)	Dietary TDI will be estimated from consumption of fish.	Concentrations of chemicals in surface sediment (intertidal and subtidal). Bulk sediment data will be used along with applicable BSAFs to estimate chemical concentrations in fish tissue.	Probability of reduced survival, growth, and reproduction of aquatic-dependent bird populations.	HQ is ratio of TDI to avian TRV based on low- and no-effects concentrations. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples of prey species may be proposed as an alternative to use of literature-derived BSAFs for estimation of dietary TDI.
Shore bird (heron)	Dietary TDI will be estimated from consumption of fish, invertebrates, and incidental consumption of intertidal sediment.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water. Bulk sediment data will be used along with applicable BSAFs to estimate chemical concentrations in fish and invertebrate tissue.	Probability of reduced survival, growth, and reproduction of aquatic-dependent bird populations.	HQ is ratio of TDI to avian TRV based on low- and no-effects concentrations. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples of prey species may be proposed as an alternative to use of literature-derived BSAFs for estimation of dietary TDI.
Shore bird (sandpiper)	Dietary TDI will be estimated from consumption of invertebrates and incidental consumption of intertidal sediment.	Concentrations of chemicals in intertidal surface sediment. Bulk sediment data will be used along with applicable biota-sediment accumulation factors (BSAFs) to estimate chemical concentrations in invertebrate tissue.	Probability of reduced survival, growth, and reproduction of aquatic-dependent bird populations.	HQ is ratio of TDI to avian TRV based on low- and no-effects concentrations. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • TDI calculation inputs • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples of prey species may be proposed as an alternative to use of literature-derived BSAFs for estimation of dietary TDI.
Piscivorous fish (e.g., rockfish)	Surface water chemical concentrations compared directly to AWQC.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water.	Probability of reduced survival, growth, and reproduction of fish populations.	HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • AWQC values	None anticipated
	Surface water chemical concentrations evaluated using TU calculations for 34 PAHs.			HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • TU calculations	None anticipated
	Fish tissue chemical concentrations will be estimated based on sediment BSAF model compared to tissue-based TRVs.			HQ is ratio of tissue burden to tissue based TRV based on low- and no-effects concentrations. [3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples may be proposed as an alternative to use of literature-derived BSAFs for this receptor.

Table 6-5 - Summary of Risk Assessment Activities for Aquatic Receptors

Bremerton Gas Works Site
Bremerton, Washington

Planned Risk Assessment Activities					Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters[1]	Contingent Testing[2]
Omnivorous fish (e.g., sculpin)	Surface water chemical concentrations will be compared directly to AWQC.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water.	Probability of reduced survival, growth, and reproduction of fish populations.	HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • AWQC values	None anticipated
	Surface water chemical concentrations will be evaluated using TU calculations for 34 PAHs.			HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • TU calculations	None anticipated
	Fish tissue chemical concentrations will be estimated based on sediment BSAF model compared to tissue-based TRVs.			HQ is ratio of tissue burden to tissue based TRV based on low- and no-effects concentrations.[3]	• Specific data to be used in evaluation • Tissue-specific BSAFs and derivation • Exposure parameters	Collection of site-specific tissue samples may be proposed as an alternative to use of literature-derived BSAFs for this receptor.
Benthivorous fish (e.g., flatfish)	Surface water chemical concentrations will be compared directly to AWQC.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water.	Probability of reduced survival, growth, and reproduction of fish populations.	HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • AWQC values	None anticipated
	Surface water chemical concentrations will be evaluated using TU calculations for 34 PAHs.			HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • TU calculations	None anticipated
	Fish tissue chemical concentrations will be estimated based on sediment BSAF model compared to tissue-based TRVs.			HQ is ratio of estimated tissue concentrations and tissue-based TRV based on low- and no-effects concentrations.[3]	• Specific data to be used in evaluation • BSAFs and derivation • Exposure parameters • Toxicity reference values	Collection of site-specific tissue samples may be proposed as an alternative to use of literature-derived BSAFs for this receptor.
Benthivorous shellfish (e.g., crab)	Surface water chemical concentrations will be compared directly to AWQC, including the PAH FCVs.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and surface water.	Probability of reduced survival, growth, and reproduction of shellfish populations.	HQ is the ratio of the concentration in surface water to the protective criteria	• Specific data to be used in evaluation • AWQC values	None anticipated
	Surface water chemical concentrations will be evaluated using TU calculations for 34 PAHs.			HQ is the ratio of the concentration in surface water to the protective criteria	• Specific data to be used in evaluation • TU calculations	None anticipated

Table 6-5 - Summary of Risk Assessment Activities for Aquatic Receptors

Bremerton Gas Works Site
Bremerton, Washington

Planned Risk Assessment Activities					Parameters to be Refined in Risk Assessment Technical Memo	
Receptor	Estimation Framework(s) for Exposure Pathway	Relevant RI Data to be Used (media and measurements)	Endpoint	Interpretative Framework	Detailed Risk Characterization Parameters[1]	Contingent Testing[2]
Benthic invertebrates (e.g., benthic infauna community)	Sediment chemical concentrations will be compared to SMS criteria for protection of benthic receptors.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and porewater.	Probability of reduced survival, growth, and reproduction of benthic invertebrate communities.	SMS criteria include the sediment cleanup objective and the cleanup screening level.	• Specific data to be used in evaluation • SMS numeric values	Site-specific sediment bioassays may be proposed as an alternative to use of numeric SMS criteria.
	Bulk sediment chemistry and total organic carbon content will be used along with literature-derived equilibrium partitioning coefficients to estimate sediment porewater concentrations for PAH compounds.			Estimated sediment porewater concentrations for 34 PAH compounds will be evaluated using the TU method.	• Specific data to be used in evaluation • Equilibrium partitioning coefficients • Toxic unit calculations	Site-specific sediment porewater collection and analysis may be proposed as an alternative to use of porewater concentration estimates derived from equilibrium partitioning coefficients.
Macrophytes (e.g., algae and kelp)	Surface water chemical concentrations will be compared directly to AWQC, including the PAH FCVs.	Concentrations of chemicals in surface sediment (intertidal and subtidal) and porewater.	Probability of reduced survival, growth, and reproduction of aquatic plant communities.	HQ is the ratio of the concentration in surface water to the protective criteria.	• Specific data to be used in evaluation • AWQC values	None anticipated
	Bulk sediment chemistry and total organic carbon content will be used along with literature-derived equilibrium partitioning coefficients to estimate sediment porewater concentrations for PAH compounds.			Estimated sediment porewater concentrations for 34 PAH compounds will be evaluated using the TU method.	• Specific data to be used in evaluation • Equilibrium partitioning coefficients • Toxic unit calculations	Site-specific sediment porewater collection and analysis may be proposed as an alternative to use of porewater concentration estimates derived from equilibrium partitioning coefficients.

Notes:

1. The risk assessment technical memorandum will present the toxicity data and risk estimation inputs to be used, and will highlight any proposed adjustments to EPA-defined default parameters.
2. If applicable, the Risk Assessment Technical Memorandum will define supplemental data collection to be used to refine risk estimates. If contingent testing is proposed, the detailed testing plan will be documented in a Sampling and Quality Assurance Plan amendment.
3. A hazard index will be used to sum HQs for different chemicals with potentially additive effects (i.e., similar toxicological mode of action).

AWQC = ambient water quality criteria
BSAF = biota-sediment accumulation factors
FCV = final chronic value
HQ = hazard quotient
PAH = polycyclic aromatic hydrocarbon

Table 6-6 – Data Quality Objectives
Nature and Extent of Contamination in Soil and Groundwater

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to identify Site COCs, determine the lateral and vertical extent of COCs in soil and groundwater, and evaluate risks.
Identify the Goal of the Study	The purpose of the monitoring activity is to: • Determine the magnitude and extent of COPC concentrations in soil and groundwater exceeding PRGs at the Site. • Determine seasonal variability in COPC concentrations in groundwater. • Determine which COPCs are Site COCs. • Determine the potential for recontamination of the Site from groundwater flowing from adjacent sites.
Identify Information Inputs	Data to be evaluated in this study include: • VOC, SVOC, and metals concentrations in soil and groundwater • Groundwater occurrence and flow characteristics
Define the Boundaries of the Study	The study area is defined by the upland portion of the ISA. Based on data collected during the study, the boundaries of the study area will be adjusted as needed to encompass the extent of where contamination from the Site has come to be located.
Develop the Analytic Approach	Analyte concentrations from soil and groundwater samples will be used to determine the study boundaries. Concentrations will be compared to PRGs based on regulatory and risk-based criteria.
Specify Performance or Acceptance Criteria	Ensure through data review and validation that the analytical data for collected samples are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. A stepwise approach is proposed to identify Site COCs and determine the extent of COCs in soil and groundwater: • Evaluate COPC concentrations in shallow soil throughout the study area using judgmental and non-judgmental sampling approaches by targeting potential source areas and implementing an approximate 50-foot sampling grid. • Evaluate COPC concentrations in deeper soil at locations based on shallow soil data. • Evaluate the lateral extent of COPCs in groundwater along the lateral boundaries of the study area by installing and sampling monitoring wells along the study area boundaries. • Evaluate the vertical extent of COPCs in groundwater through installation of deep monitoring wells. Deep monitoring well placement will be based on evaluation of shallow groundwater data, soil data, and observed geologic characteristics. • Conduct quarterly monitoring of COPCs in groundwater at monitoring wells for a minimum of 1 year to assess seasonal variability.

Table 6-7 – Data Quality Objectives
Sources of Contamination (Upland)

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to identify the location of historical sources of contamination at the Site.
Identify the Goal of the Study	The purpose of the monitoring activity is to: • Determine likely locations where contaminants may have been released for the purposes of targeting subsurface investigations. • Evaluate the potential presence of subsurface features that may act as a source of contamination.
Identify Information Inputs	Data to be evaluated in this study include: • Historical information, including aerial photographs • Utility and ground-penetrating radar surveys • Subsurface survey through observation of targeted, shallow excavations
Define the Boundaries of the Study	The study area is defined by the extent of historical gas works operations, including the fill areas in the former ravine and along the shoreline.
Develop the Analytic Approach	Collected information, survey data, and observations will be used to identify areas for further exploration and sampling.
Specify Performance or Acceptance Criteria	This is a qualitative evaluation.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. A stepwise approach is proposed to identify potential sources: • Available additional historical information and utility/radar surveys will be used to update site maps of potential sources and target explorations • Historical and survey data will be used to locate shallow excavations (test pits or trenches) • Alignment of buried pipes, if encountered, will be further located as practicable using utility location techniques.

Table 6-8 – Data Quality Objectives
Site Physical Characteristics

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to characterize Site physical characteristics.
Identify the Goal of the Study	The purpose of the monitoring activity is to: • Determine soil lithology and physical properties of lithologic units • Determine hydraulic characteristics of Site aquifer units • Understand role of tidally-influenced surface water on groundwater flow • Evaluate whether Site groundwater is a potential drinking water source
Identify Information Inputs	Data to be evaluated in this study include: • Logging of Site soil lithology from subsurface explorations • Physical soil characteristics, including gradation, density, Atterberg limits, penetration tests, and moisture content • Hydraulic conductivity of aquifer units • Water levels at site wells throughout seasonal and tidal cycles • Salinity data at Site monitoring wells
Define the Boundaries of the Study	The study area is defined by the upland portion of the ISA. The boundaries of the study area will be adjusted as needed to encompass the extent of where contamination from the Site has come to be located.
Develop the Analytic Approach	Identify distinct lithologic and aquifer units through soil sampling. Submit representative samples from each unit for physical testing. Conduct hydraulic testing of aquifer units at representative monitoring wells.
Specify Performance or Acceptance Criteria	Physical data will be collected and analyzed using standard test measurements and procedures. Soil lithology characterization and sampling will be performed under the supervision of a professional geologist. Hydraulic testing will be performed under the supervision of a professional hydrogeologist.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. All subsurface explorations at the Site will be logged, and representative samples from each distinct lithologic unit will be analyzed for physical parameters. Hydraulic testing will be performed for contaminated aquifer units after the vertical and lateral limits of contaminated groundwater are determined.

Table 6-9 – Data Quality Objectives
NAPL Characterization
Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to identify if NAPLs (LNAPLs or DNAPLs) are present at the Site. If NAPLs are present, additional information is required to characterize the extent of NAPLs, their physical and chemical characteristics, and their potential mobility.
Identify the Goal of the Study	The purpose of the monitoring activity is to: • Determine if significant quantities of NAPL are present in the subsurface at the Site • Determine the lateral and vertical boundaries of NAPL occurrences if identified • Characterize soil characteristics surrounding NAPL occurrences if present • Identify physical and chemical characteristics of NAPL if present • Evaluate NAPL mobility if present
Identify Information Inputs	Data to be evaluated in this study include: • Logging of Site soil lithology from subsurface explorations • Field observations of potential NAPL indicators • Chemical concentrations of COPCs in soil samples where NAPL may be observed • Measurements of NAPL presence and thickness in monitoring wells • Analysis of NAPL samples for physical properties, including viscosity, density, and flash point, and chemical composition (if present)
Define the Boundaries of the Study	The study area is defined by the upland portion of the ISA. The boundaries of the study area will be adjusted as needed to encompass the extent of where contamination from the Site has come to be located.
Develop the Analytic Approach	Assess subsurface soil during logging for the potential presence of NAPL and to characterize soil lithology around potential NAPL occurrences. If potential NAPL is observed, collect soil samples from potential NAPL-impacted soil for chemical analysis. Install monitoring wells at locations of potential NAPL occurrence and gauge for NAPL presence and thickness. If measurable NAPL is observed in monitoring wells, collect NAPL samples for laboratory analysis if present. If NAPL is observed in the subsurface, contingent studies for characterizing the lateral and vertical extent of NAPL include the TarGOST technology (see Section 6.6). If sufficient NAPL is measured in monitoring wells, contingent studies for characterizing mobility and recoverability of NAPL include baildown testing at representative wells containing NAPL (see Section 6.6).
Specify Performance or Acceptance Criteria	Physical and chemical testing of NAPL samples to be conducted following EPA-approved and/or standard test methods. Soil logging to be performed under the supervision of a professional geologist.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP.

Table 6-10 – Data Quality Objectives
Contaminant Fate and Transport

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to characterize contaminant transport and attenuation at the Site.
Identify the Goal of the Study	The purpose of the monitoring activity is to: • Evaluate contaminant transport within and between environmental media • Evaluate potential mechanisms for contaminant attenuation
Identify Information Inputs	Data to be evaluated in this study include: • Logging of Site soil lithology from subsurface explorations • Total organic carbon in soil and sediment • Chemical concentrations of COPCs in soil, groundwater, sediment, and surface water • Conventional geochemical parameters in groundwater, including nitrate, nitrite, sulfate, sulfide, alkalinity, ferrous and ferric iron, dissolved manganese, organic carbon, dissolved oxygen, pH, temperature
Define the Boundaries of the Study	The study area is defined by the ISA. The boundaries of the study area will be adjusted as needed to encompass the extent of where contamination from the Site has come to be located.
Develop the Analytic Approach	Assess subsurface soil lithology to evaluate potential preferential migration pathways. Collect and analyze representative samples of each lithologic unit for total organic carbon for evaluations of leaching and sorption. Qualitatively evaluate geochemical parameters, in conjunction with COPC data, to assess potential for ongoing natural attenuation of contaminants. Conduct vapor intrusion modeling to assess potential COPC concentrations in indoor air if structures were present. If the extent of contamination and modeling results indicate a potential exposure risk, soil vapor and/or indoor air sampling may be conducted. See Section 6.6, contingency studies.
Specify Performance or Acceptance Criteria	Ensure through data review and validation that the analytical data for collected samples are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. Lithologic characterization and collection of samples for total organic carbon analysis will be performed during soil and sediment investigations. Geochemical monitoring will be included in groundwater monitoring program.

Table 6-11 - Data Quality Objectives
Habitat and Intertidal Shellfish

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to confirm intertidal and subtidal habitat conditions within Port Washington Narrows and to evaluate the exsisting distribution and abundance of shellfish within beach areas near the Site. The information will be used to confirm assumptions for evaluation of human health and ecological exposure scenarios.
Identify the Goals of the Study	• Evaluate intertidal and subtidal habitat characteristics within the Site and vicinity, including differences in sediment grain size, vegetation, epifauna, and other fish and wildlife. • Quantify the existing abundance of potentially harvestable shellfish resources in beach areas of the initial study area (ISA) and Port Washington Narrows to help inform the evaluation of human health risks associated with potential future shellfish harvesting.
Identify Information Inputs	• Visual surveys of intertidal and subtidal habitat characteristics within the Site and vicinity, including differences in sediment grain size, vegetation, epifauna, and other fish and wildlife. • Direct measurements of abundance of potentially harvestable shellfish resources in beach areas of the ISA and Port Washington Narrows.
Define the Boundaries of the Study	• Visual surveys of intertidal and subtidal habitat characteristics will extend throughout the ISA, including transects located in parallel and perpendicular to the axis of the narrows and located along different depth profiles. • Surveys of potentially harvestable shellfish resources will include testing locations both within and outside of the ISA, including selected beach areas located to the east and west within Port Washington Narrows.
Develop the Analytic Approach	• Visual surveys will be performed using a towed camera with integrated DGPS position logging so that all visual observations may be georeferenced. • Surveys of potentially harvestable shellfish resources will be performed using methods developed by the Washington Department of Fish and Wildlife for this purpose.
Specify Performance or Acceptance Criteria	• The DGPS position logging will be verified during the visual surveys to confirm the accuracy of survey locating. The visual quality of the survey will be monitored during collection with a real-time video feed to verify the usability of collected footage. • Surveys of potentially harvestable shellfish resources will comply with quality assurance/quality control protocols developed by the Washington Department of Fish and Wildlife.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying Sampling and Quality Assurance Project Plan (SQAPP). • Visual surveys will be conducted by towed camera surveys with position logging and real-time video feed for confirming data acquisition. Planned survey transects are defined in the SQAPP. • Shellfish surveys will be conducted during low-tide events following applicable WDFW methodologies. The planned sampling locations are defined in the SQAPP.

Table 6-12 - Data Quality Objectives
Nature and Extent of Site-related Contamination in Surface Sediment

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to determine the lateral extent of contaminants of potential concern (COPCs) in intertidal and subtidal surface sediment (0–4-inch depth interval) within the ISA and to provide the information necessary to support the evaluation of risks to human health and ecological receptors exposed to surface sediment.
Identify the Goals of the Study	• Verify the list of COPCs developed during Remedial Investigation/Feasibility Study (RI/FS) scoping for marine Site areas. • Determine the nature and extent of Site-related COPCs in surface sediment, including delineation of areas exceeding applicable preliminary remediation goals (PRGs). • Provide inputs (surface sediment COPC concentrations and sediment total organic carbon) useful for quantifying exposure to human health and ecological receptors. • Evaluate Site-specific polycyclic aromatic hydrocarbon (PAH) bioavailability in sediment porewater relative to literature-derived partitioning coefficients. • Document surface sediment grain size for use in evaluation of sediment stability.
Identify Information Inputs	• Initial sampling in potential source areas for conventional parameters, grain size, marine sediment COPC (PAHs, including parent and alkylated homologs) and additional compounds (semivolatile organic compounds, heavy metals, and total and available cyanide) not identified as COPC during RI/FS scoping. • Sampling for PAHs, including parent and alkylated homologs, grain size, and conventional parameters in intertidal and subtidal surface sediment within the ISA. • Paired sampling of PAHs in bulk sediment and porewater at selected locations.
Define the Boundaries of the Study	The study area is defined by the sediment portion of the ISA. Additional sampling of surface sediment in Port Washington Narrows areas outside of the ISA will be conducted in parallel to support FS evaluations of potential recontamination (see Table 6-16).
Develop the Analytic Approach	• Bulk sediment COPC concentrations will be quantified using U.S. Environmental Protection Agency (EPA)-approved methods capable of meeting reporting limits below applicable PRGs or sediment natural background concentrations for Puget Sound sediments. • Testing for PAHs will include both parent and alkylated homologs. • Porewater PAH concentrations will also be evaluated using the EPA (2003) equilibrium partitioning sediment benchmark framework.
Specify Performance or Acceptance Criteria	Ensure thorough data review and validation that the analytical data for collected samples are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. • Initial sampling locations were identified during RI/FS scoping and discussions with the EPA project team based on historical source areas, trends noted during previous sampling, and an analysis of potential sediment fate and transport processes. The sampling plan is detailed in the SQAPP. • The Administrative Order on Consent (AOC) and RI/FS Work Plan include contingencies for additional sampling, should the nature and extent of Site-related contamination not be fully delineated during the initial sampling effort.

Table 6-13 - Data Quality Objectives
Nature and Extent of Site-related Contamination in Subsurface Sediment

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to determine the lateral and vertical extent of COPCs in intertidal and subtidal subsurface sediment (greater than 4-inch depth interval) within the ISA and to provide information necessary to support the evaluation of human health risks for exposures to subsurface sediment in intertidal areas.
Identify the Goals of the Study	• Determine the nature and extent of COPC concentrations in subsurface sediment exceeding applicable PRGs. • Provide inputs (subsurface sediment COPC and TOC concentrations) useful for quantifying exposure to human health receptors in intertidal areas • Evaluate the potential presence and distribution of Site-related NAPL and hydrocarbon sheen in subsurface sediments to evaluate potential contaminant migration pathways. • Document subsurface sediment grain size and stratigraphy for use in evaluation of sediment stability and remedial alternatives
Identify Information Inputs	• Document sediment stratigraphy at each coring location, including screening for potential presence of NAPL, hydrocarbon contamination or other anthropogenic impacts. • Quantify concentrations of confirmed COPC (including at a minimum PAHs) in subsurface sediments from a minimum of two depth intervals, representing the zone of highest apparent contamination and the top of the uncontaminated sediment layer. Analysis of additional archived sediment samples may be required depending on the results of initial sample analysis. • Confirm sediment stratigraphy with selected analysis of sediment grain size.
Define the Boundaries of the Study	The study area includes the intertidal and subtidal areas adjacent to the Former Gas Works source areas, and locations extending outward and down-slope to the base of Port Washington Narrows as necessary to evaluate potential contaminant migration
Develop the Analytic Approach	• Bulk sediment COPC concentrations will be quantified using EPA-approved methods capable of meeting reporting limits below applicable PRGs or sediment natural background concentrations for Puget Sound sediments. • Testing for PAHs will include parent compounds (analysis for alkylated homologs is not required for this sampling activity).
Specify Performance or Acceptance Criteria	Ensure thorough data review and validation that the analytical data for collected samples are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The plan for obtaining data is presented in this work plan and accompanying SQAPP. • Initial sampling locations were identified during RI/FS scoping and discussions with the EPA project team based on historical source areas and an analysis of potential sediment fate and transport processes. This sampling plan is identified in the SQAPP. • The AOC and RI/FS Work Plan include contingencies for additional sampling should the nature and extent of Site-related contamination not be fully delineated during the initial sampling effort.

Table 6-14 - Data Quality Objectives
Nature and Extent of Site-related Contamination in Surface Water
Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to determine the potential presence and concentrations of Site-related COPC in surface water and to support the evaluation of human health and ecological risks.
Identify the Goals of the Study	• Determine the potential presence and concentrations of confirmed Site-related COPC concentrations in water at the Site. • Distinguish between Site-related COPC impacts to surface water and surface water impacts from off-Site sources.
Identify Information Inputs	• Measurement of confirmed Site-related COPC (including parent and alkylated PAHs) in surface water at locations within the ISA and at background stations within Port Washington Narrows. • Parallel testing for conventional parameters, including total organic carbon, dissolved organic carbon and total suspended solids, dissolved oxygen, pH, salinity, and temperature.
Define the Boundaries of the Study	The study area includes both locations within the ISA near historical source areas and background locations within Port Washington Narrows but distant from the ISA.
Develop the Analytic Approach	• Surface water COPC concentrations will be quantified using EPA-approved methods capable of meeting reporting limits below applicable PRGs to the extent practicable. • Testing for PAHs will include both parent compounds and alkylated homologs.
Specify Performance or Acceptance Criteria	Ensure thorough data review and validation that the analytical data for collected samples are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. • Surface water sampling locations include two areas within the ISA that could potentially be impacted by releases from groundwater or sediment. Two background locations within Port Washington Narrows are included to help differentiate potential Site-related impacts and contamination from off-Site sources. • Multiple rounds (four) of sampling are included to assess the potential variability in surface water contaminant concentrations.

Table 6-15 - Data Quality Objectives
Marine Area Sediment Stability and Recontamination Processes

Bremerton Gas Works Site
Bremerton, Washington

Step	Description
State the Problem	Additional information is necessary to evaluate the stability of existing Site sediments and to support the evaluation of potential recontamination from migration of off-Site sediments.
Identify the Goals of the Study	• Quantify near-bottom tidal currents within Port Washington Narrows for use, along with sediment grain size distribution quantified in other RI activities, in evaluating the stability of the existing bed sediments within the Site. • Quantify the concentrations of PAH (and, if applicable, other Site-related COPC) in surface sediments in off-Site areas of Port Washington Narrows to support the FS evaluation of potential sediment recontamination processes.
Identify Information Inputs	• Measurements of the direction and velocity of peak tidal currents in near-bottom areas of Port Washington Narrows during strong ingoing and outgoing tides. • Measurements of the concentrations of PAH (and, if applicable, other Site-related COPC) in surface sediments in off-Site areas of Port Washington Narrows to support the FS evaluation of potential sediment recontamination processes.
Define the Boundaries of the Study	• The boundary for the tidal current study includes four transects extending south to north across Port Washington Narrows extending from the Former Gas Works and adjacent beach areas out beyond the boundaries of the ISA . • The boundary for the study of surface sediment quality within Port Washington Narrows extends from the ISA east and west to the ends of Port Washington Narrows.
Develop the Analytic Approach	• Tidal currents will be measured using a vessel-mounted Acoustic Doppler Current Profiler in order to document changes in tidal currents with depth, location, and time during the course of a daily tide cycle with strong ingoing and outgoing tides. • Bulk sediment COPC concentrations in surface sediments of Port Washington Narrows will be quantified using EPA-approved methods capable of meeting reporting limits below applicable PRGs or sediment natural background concentrations for Puget Sound sediments. Testing for PAHs will include parent compounds (analysis for alkylated homologs is not required for this sampling activity).
Specify Performance or Acceptance Criteria	Ensure through data review and validation that the measurement data are within acceptable quality limits as defined by applicable EPA data quality protocols.
Develop the Plan for Obtaining Data	The detailed plan for obtaining data is presented in this work plan and accompanying SQAPP. • Tidal surveys will be conducted by a qualified contractor along transects at the specified locations during a tidal cycle with strong ingoing and outgoing tides. • Sediment sampling locations were selected to include both areas subject to potential sediment movement by littoral drift and sediments subject to potential current-induced sediment movement. Sampling locations were adjusted to avoid areas likely to be impacted by known or suspected contaminated sites or potential pollution sources.

Table 6-16 Summary of Marine Sampling Design

Bremerton Gas Works Site
Bremerton, Washington

Area	Sub-Area	Sample Type	Purposes	Number of Samples and Location Rationale	Primary Testing Parameters [1]
Sediment Sampling					
Initial Study Area	Co-Located Intertidal and Subtidal Sediment Grabs and Cores	Intertidal Grab Samples	To define the horizontal nature and extent of contamination in intertidal sediments	Bulk chemistry at 5 intertidal stations collected throughout beach area adjacent to former Gas Works and ravine	PAHs (including alkylated), TS, TOC, grain size
			Evaluate concentrations of metals, SVOC and cyanide along Gas Works intertidal area	Supplemental testing for bulk chemistry at 5 intertidal stations adjacent to former Gas Works and ravine	Cyanide (total and available), metals and SVOC
			Evaluate pore-water concentrations of PAH and alkylated PAH concentrations	Pore-Water chemistry at 5 intertidal stations	PAHs (including alkylated) in pore-water
		Subtitdal Grab Samples	To define the horizontal nature and extent of contamination in subtidal sediments	14 subtidal stations collected in transects down the slope toward to the channel elevation.	PAHs (including alkylated), TS, TOC, grain size
		Vibracores	To define the vertical nature and extent of contamination in intertidal and subtidal sediments in including NAPL and Sheens	5 intertidal and 12 subtidal stations Advanced in transects down the slope toward to the channel elevation and two within the marina.	PAHs, TS, TOC
	Other Intertidal and Subtidal Sediment Grabs	Intertidal Grabs	Provide bounding to the nature & extent of site-associated impacts in intertidal sediment	2 stations Step-out sampling in accessible intertidal areas within eastern extent of the ISA. The western intertidal extent is a rip rap armored slope and not generally accessible.	PAHs (including alkylated), TS, TOC, grain size
		Subtidal Grabs	To define the horizontal nature and extent of contamination in subtidal sediments	12 stations Step-out sampling between slope area and ISA boundary.	PAHs (including alkylated), TS, TOC, grain size
Port Washington Narrows	Intertidal	Surface Grab (Multi-Increment Composite)	Document quality of intertidal sediments within Port Washington Narrows to provide an estimate of recontamination potential from sediment movement (littoral drift and bed load) and deposition	11 stations Collection along north side and five along the south side of the narrows. Stations placed in publically accessible intertidal areas.	PAHs (including alkylated), TS, TOC, grain size
			Evaluate relationship between predicted and actual pore-water concentrations of PAH and alkylated PAH	5 stations Representative samples of Narrows intertidal samples (every other sample). Allows estimate of central tendency.	PAHs (including alkylated)
	Subtidal (Channel Bottom)	Surface Grab	Document quality of intertidal sediments within Port Washington Narrows to provide an estimate of recontamination potential from sediment movement (sediment bed load) and deposition	6 stations Collection along the general centerline and deeper sections of the channel.	PAHs (including alkylated), TS, TOC, and Grain Size
Surface Water Sampling					
Initial Study Area	Surface Water	Grab	Quantify concentrations of site-associated COPCs in surface water	2 locations Seasonal sampling at 2 depths per location	Conventional Parameters, PAHs (including alkylated)
Port Washington Narrows		Grab	Quantify concentrations of COPCs in surface water to assess potential regional influences	2 locations Seasonal sampling at 2 depths per location	Conventional Parameters, PAHs (including alkylated)
Habitat and Physical Surveys					
Initial Study Area and Port Washington Narrows	Intertidal	Visual & Photo Survey	Conduct surveys of aquatic habitat and fish/shellfish resources near the Site within Port Washington Narrows.	5 locations within ISA intertidal area, and 11 locations within Port Washington Narrows	Visual survey for clam identification and abundance
	Subtidal	Towed-Camera Survey	Refine environmental setting information	6 transects perpendicular to and 5 transects in parallel with the Port Washington Narrows	Mapping of substrate, vegetation and identified aquatic species
Initial study area	Subtidal	ADCP Transects	Measure Near-bottom currents that may impact sediment stability	4 transects perpendicular to Port Washington Narrows (2 tide conditions)	Conduct empirical measurements of near-bottom and mid-channel tidal currents for use in an analysis of sediment stability.

Notes:

1. Samples to be archived frozen for contingent analysis should additional testing be required for SVOC or heavy metals.

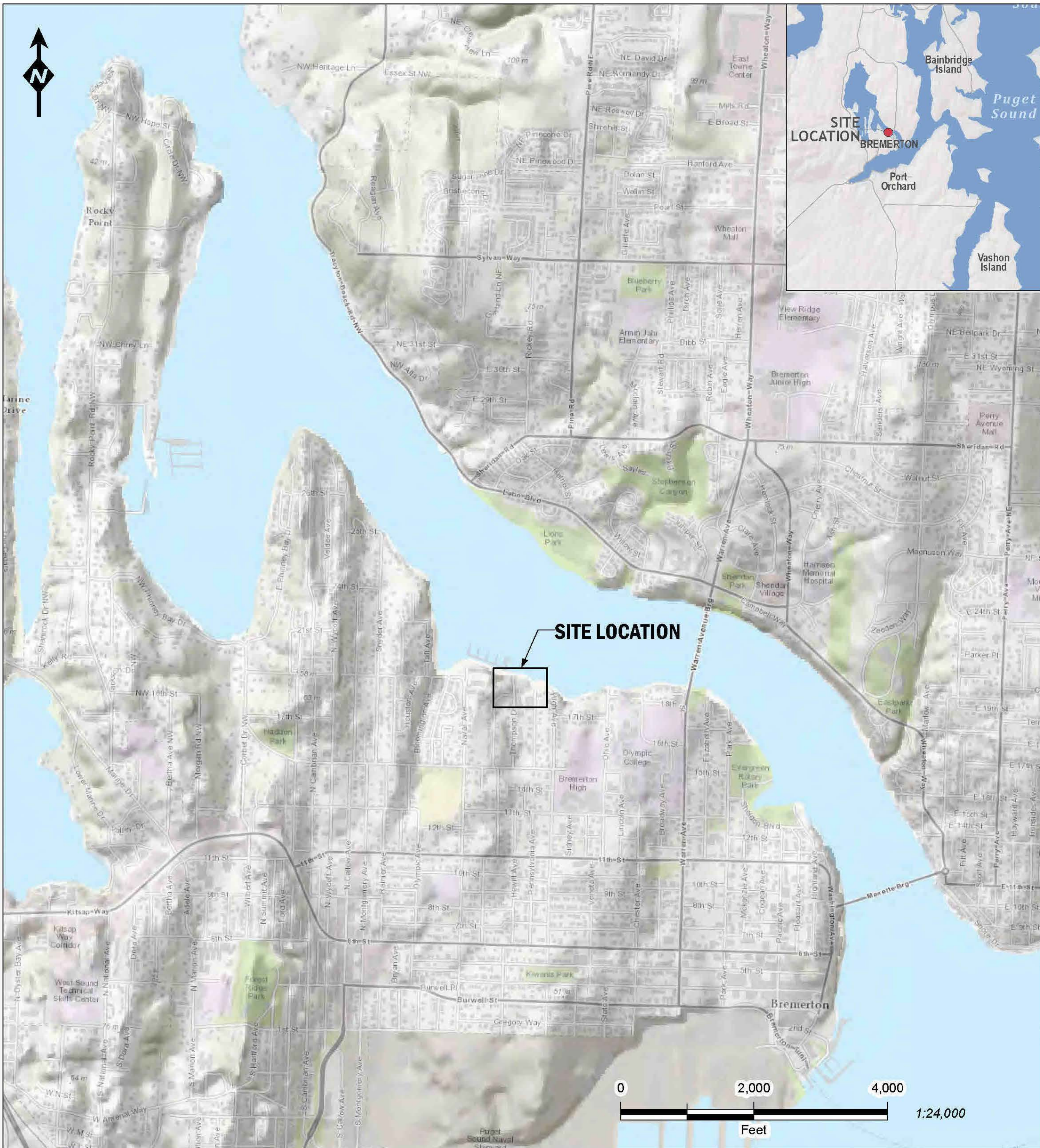
PAH = polynuclear aromatic hydrocarbons   NA = not applicable   TOC = total organic carbon   NAPL = non-aqueous phase liquid   SVOC = semi-volatile organic compound
TS = total solids   TBD = to be determined   ADCP = acoustic doppler current profiler   COPCs = chemicals of potential concern

Table 8-1 - Estimated Remedial Investigation Data Collection Schedule

Bremerton Gas Works Site
Bremerton, Washington

Task	Deliverables (Decision Process and Documents)	Decision Process (Decision Process and Documents)	Task Duration (Working Days)	Linkage	Time to Completion (Working Days from Work Plan Approval)	Estimated Date
Work Plan Approval Date						June 24, 2015
Upland Investigation						--
Contractor coordination and mobilization			20	WP approval	20	July 22, 2015
Utility and geophysical surveys			10	contractor mobilization	30	August 5, 2015
Evaluate survey results, assess exploration locations	*Survey results, revised maps*	*Meeting or Conference Call*	5	utility surveys	35	August 12, 2015
Shallow soil investigation - test pits			15	revised explorations	50	September 2, 2015
Receive preliminary soil data from test pits and perimeter borings, assess scope for probes	*preliminary data tables, test pit logs, revised exploration maps*	*Meeting*	20	test pit explorations	70	September 30, 2015
Shallow soil investigation - probes			10	meeting on test pit data	80	October 14, 2015
Receive preliminary soil data from probes, assess need for additional explorations	*preliminary data tables, boring logs, revised exploration maps*	*Meeting*	20	probe explorations	100	November 11, 2015
Shallow soil investigation - probes (stepouts: if necessary)			5	meeting on probe data	105	November 18, 2015
Receive preliminary soil data from step-out borings, assess scope for wells	*preliminary data tables, boring logs, revised exploration maps*	*Meeting*	20	stepout probe explorations	125	December 16, 2015
Contractor coordination and mobilization - deep borings/wells			15	meeting on well scoping	140	January 6, 2016
Perimeter deep borings/water table wells - MW-9WT through MW-14WT			5	contractor mobilization - deep borings	145	January 13, 2016
Deep borings/Deep Wells - MW-101-X through MW-105-X			10	meeting on well scoping	150	January 20, 2016
Interior deep borings/water table wells - MW-15WT through MW-19WT			5	perimeter and deep borings/wells	155	January 27, 2016
Well development and surveying			15	interior water table wells	170	February 17, 2016
1st Quarter - groundwater sampling			10	well development	180	March 2, 2016
Receive preliminary groundwater data, assess scope of monitoring program and need for additional deep or water table wells	*preliminary data tables, monitoring schedule, proposed exploration maps*	*Meeting*	20	groundwater sampling	200	March 30, 2016
Additional groundwater wells (if necessary)			15	meeting on groundwater data	215	April 20, 2016
Well development and surveying			5	additional wells	220	April 27, 2016
2nd Quarter - groundwater sampling			10	1st quarter groundwater sampling	270	July 6, 2016
Receive preliminary groundwater data, identify wells for hydraulic testing and tidal study	*preliminary data, boring/well construction logs, proposed wells for hydraulic testing*	*Meeting or Conference Call*	20	2nd quarter groundwater sampling	290	August 3, 2016
Well hydraulic testing and tidal studies			60	meeting on hydraulic testing	350	October 26, 2016
3rd Quarter - groundwater sampling			10	2nd quarter groundwater sampling	360	November 9, 2016
4th Quarter - groundwater sampling			10	3rd quarter groundwater sampling	450	March 15, 2017
Marine Area Investigations						--
Round 1A Marine Investigation						--
Survey Activities Towed camera video survey (tidally dependent) ADCP Current Survey (tidally dependent) Source-Area COPC Verification Mobilization, sampling, analysis, and validation (tidally dependent)	*As-collected sampling figure and validated analytical results.*	*Meeting*	100	WP approval	100	November 11, 2015
Round 1B Marine Investigation						--
Surface Sediment Sampling within ISA Surface Sediment Sampling within Port Washington Narrows Subsurface Sediment Investigation Surface Water Sampling Shellfish Survey	*As-collected sampling figure and validated analytical results.*	*Meeting*	280	Sediment COPC and subsurface scope verification in coordination with EPA	380	December 7, 2016
Phase 1 Data Report (Includes Risk Assessment Tech Memo and WP Addendum, if applicable)						--
Phase I Data Report		Submittal	90	Receipt of final validated surface water data	470	April 12, 2017

FIGURES



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Bremerton Gas Works Site
Bremerton, Washington

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR | DRAWN BY: HRL | FIGURE NO. **1-1**

Basemap Layer Credits || Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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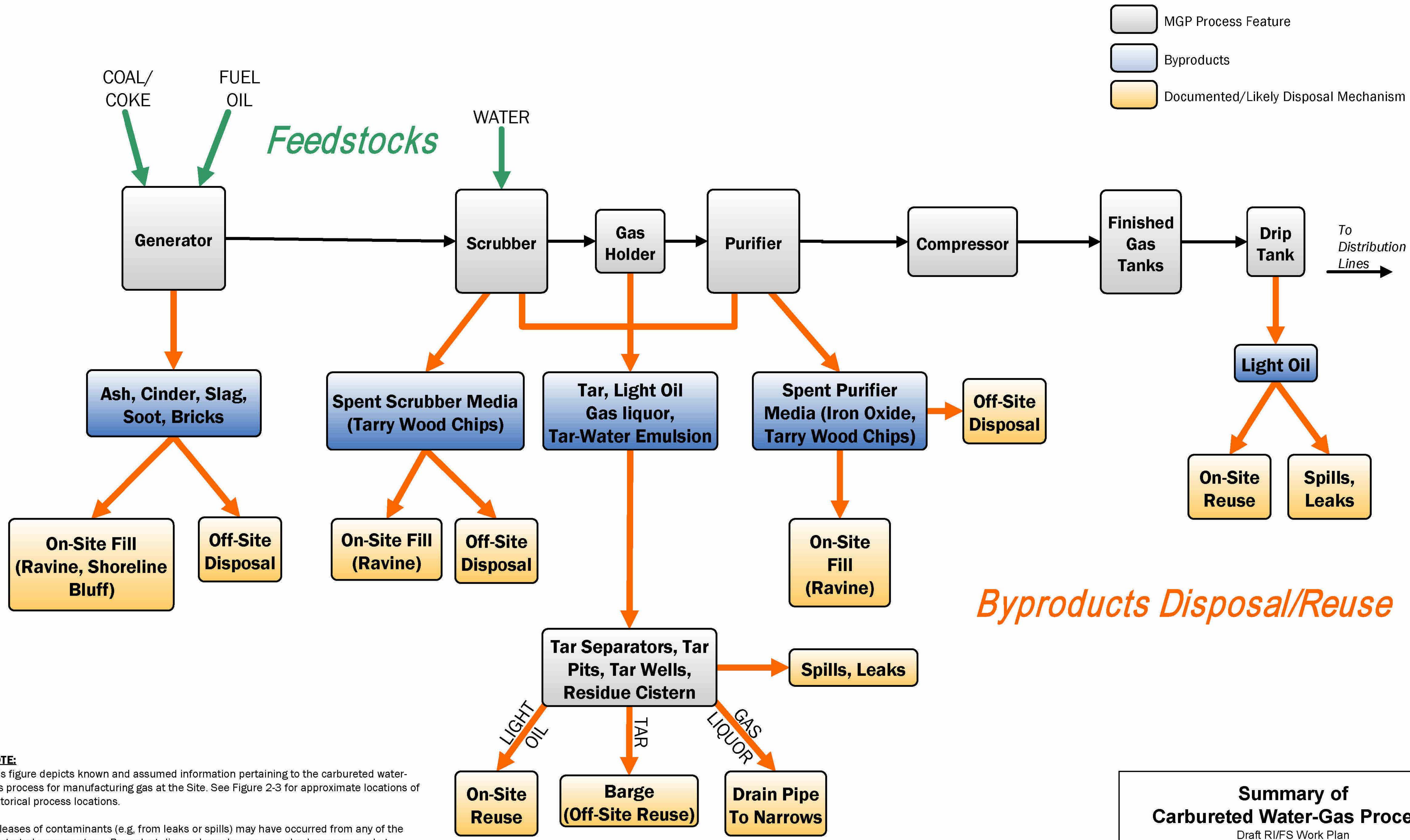


NOTE:

This figure depicts known and assumed information pertaining to the carbureted water-gas process for manufacturing gas at the Site. See Figure 2-3 for approximate locations of historical process locations.

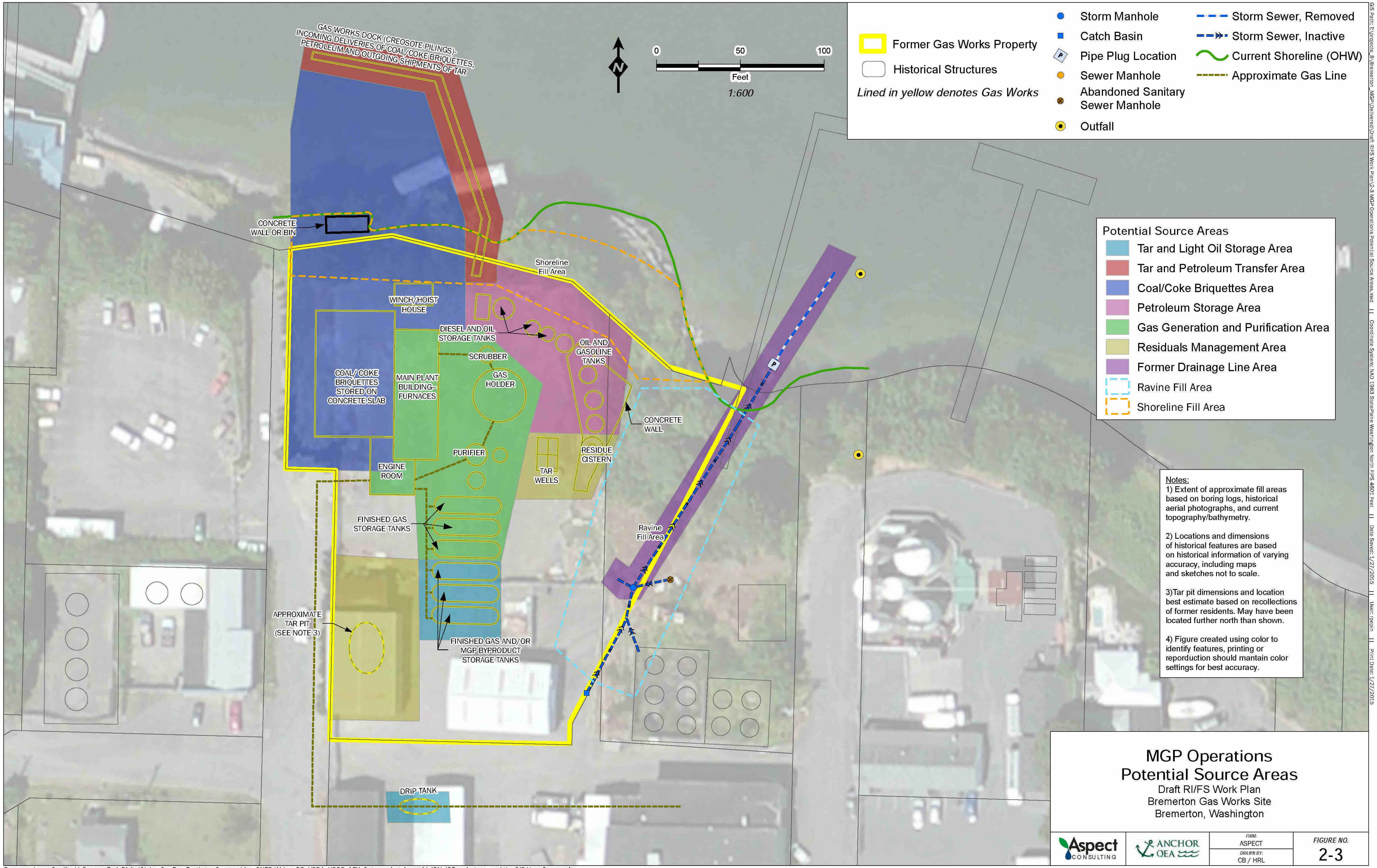
Releases of contaminants (e.g, from leaks or spills) may have occurred from any of the illustrated process steps. Byproduct disposal or releases may also have occurred at undocumented locations within or outside of the gas works operational area. Refer to Section 5 – Preliminary Conceptual Model for discussion of potential sources of contamination and release mechanisms.

Summary of Carbureted Water-Gas Process

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: JJP/HRL | FIGURE NO. 2-2

VISIO PATH: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\2-2 Summary of Carbureted Water Gas Process.vsd | 2/18/2015



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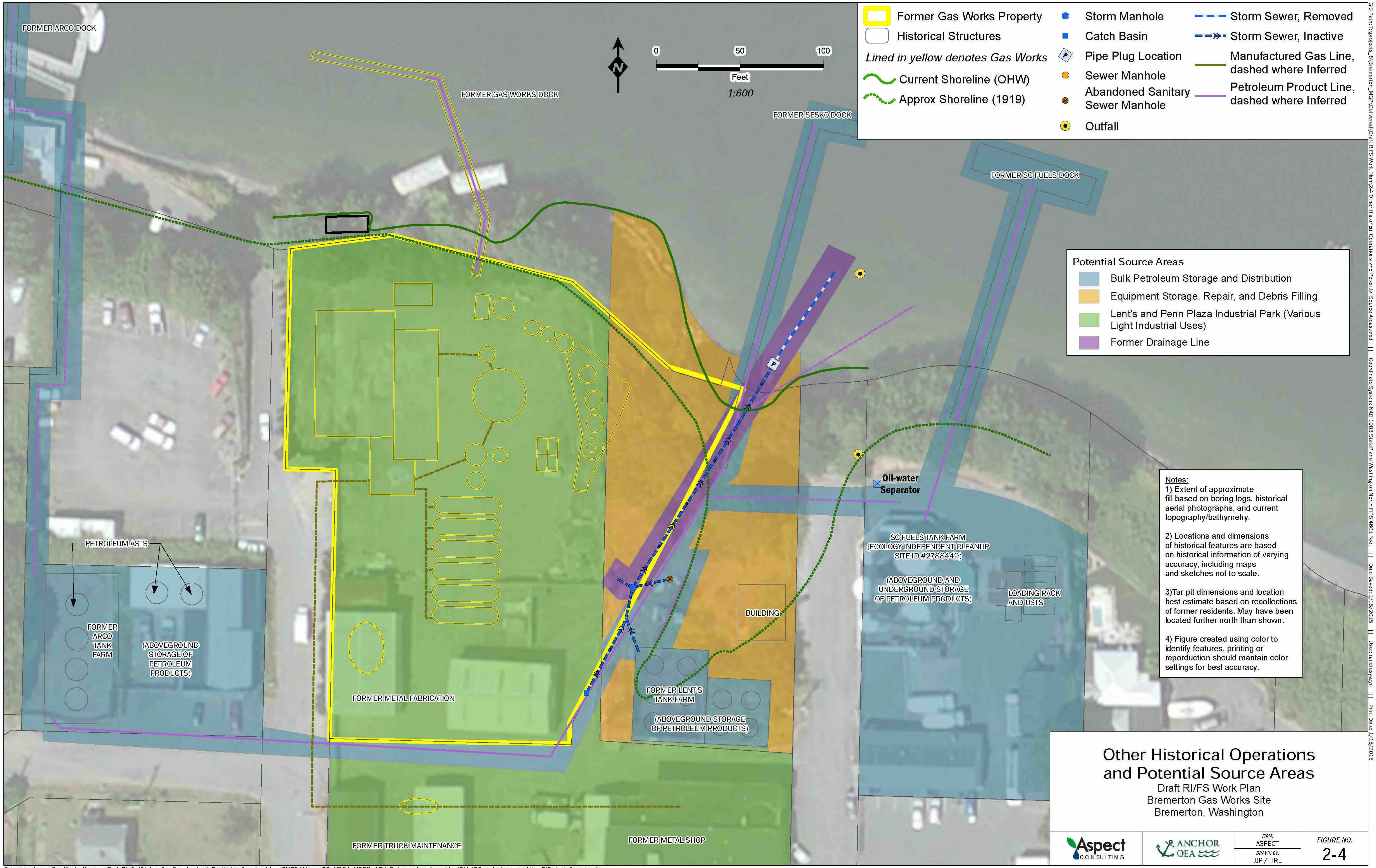

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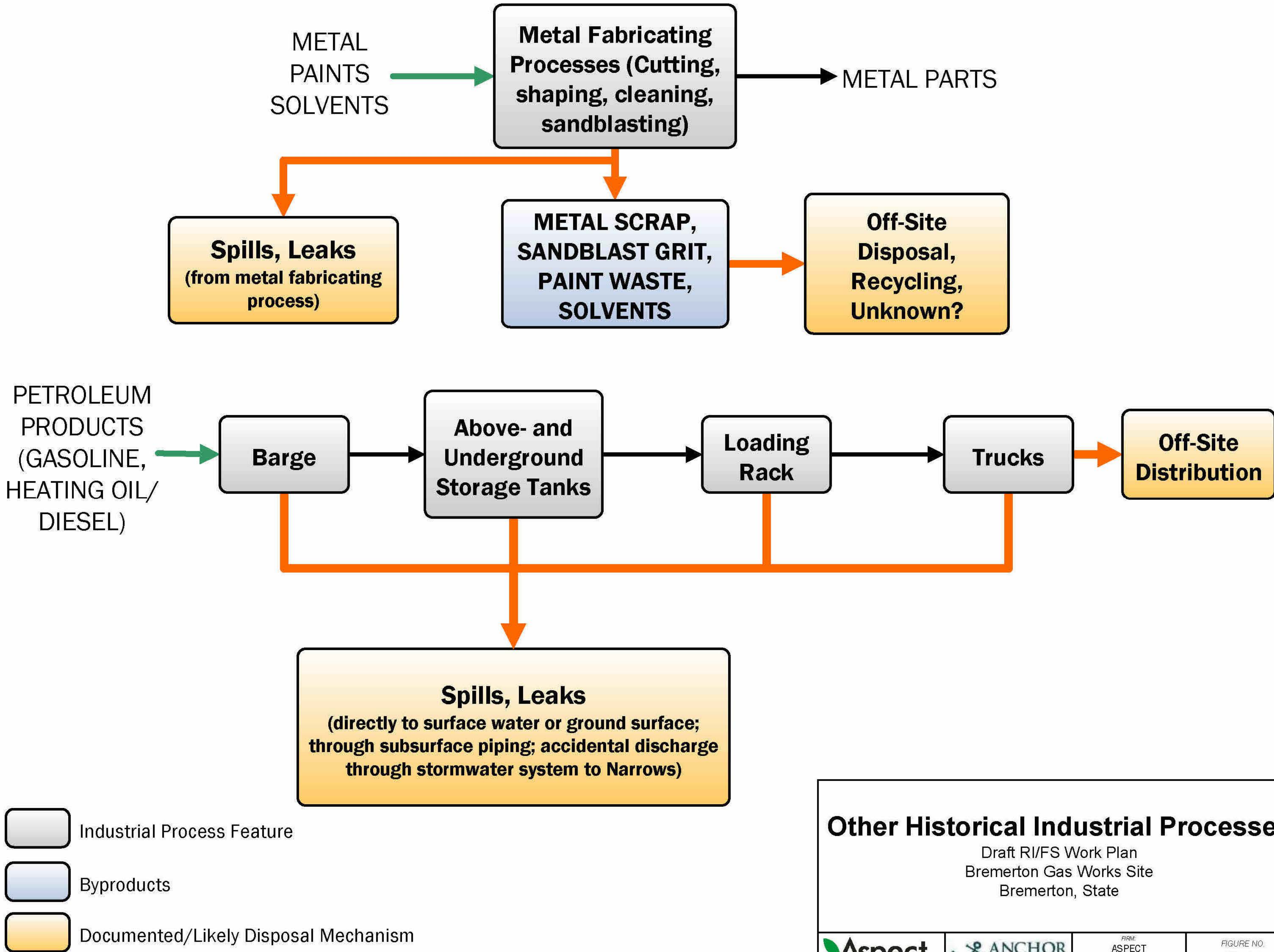
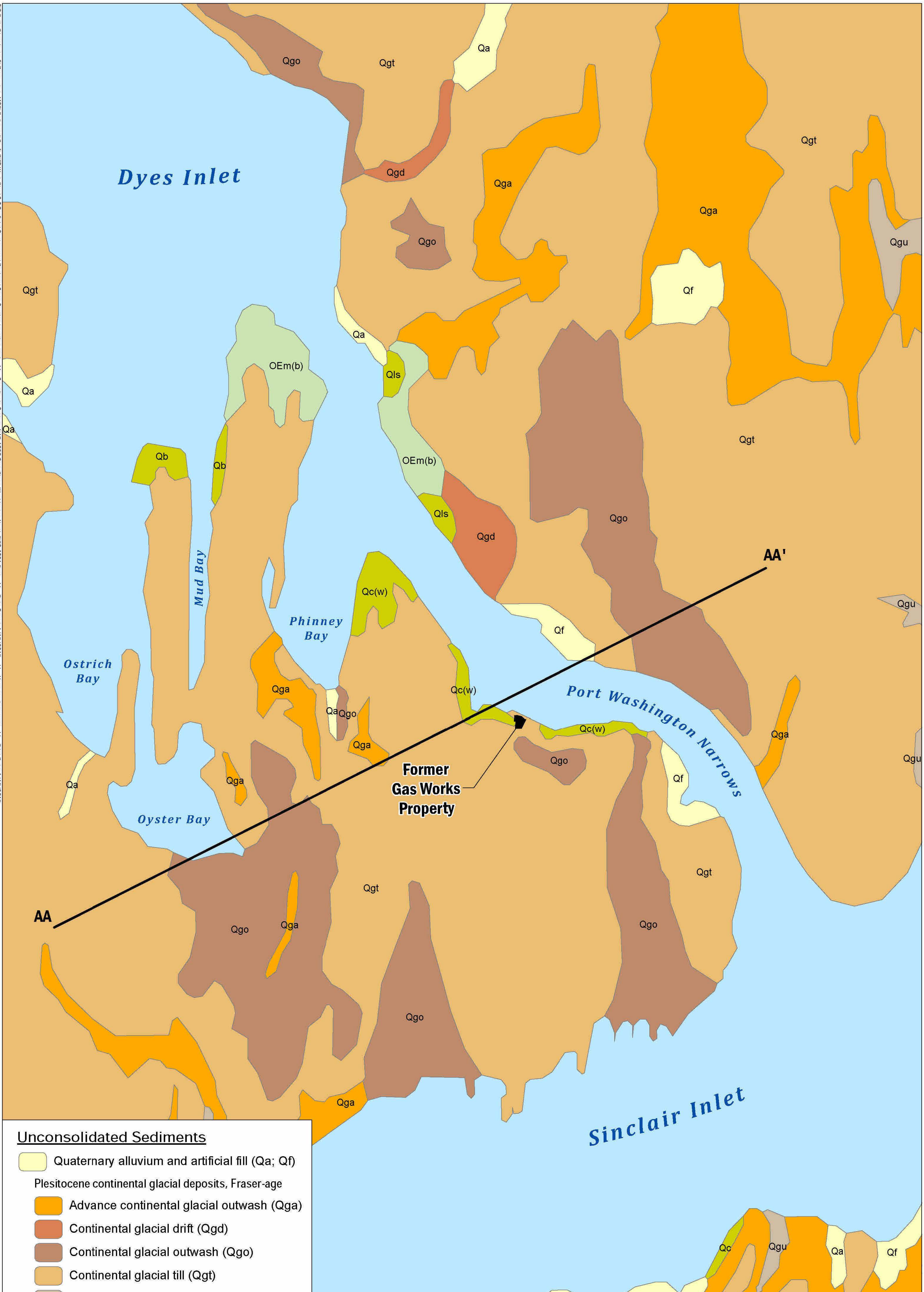


Other Historical Industrial Processes

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, State

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT; DRAWN BY: JJP / HRL | FIGURE NO. 2-5

VISIO PATH: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\2-5 Other Historical Processes.vsd | 2/18/2015



Unconsolidated Sediments

- Quaternary alluvium and artificial fill (Qa; Qf)

Plesitocene continental glacial deposits, Fraser-age

- Advance continental glacial outwash (Qga)
- Continental glacial drift (Qgd)
- Continental glacial outwash (Qgo)
- Continental glacial till (Qgt)
- Glacial drift, undivided (Qgu)
- Quaternary alluvial fans, beach deposits, undifferentiated sedimentary deposits, lacustrine deposits, landslides, peat, terraced deposits, and talus (Qb; Qc; Qc(w); Qls)

Sedimentary Rocks and Deposits

- Oligocene-Eocene marine sedimentary rocks (OEm(b))

N

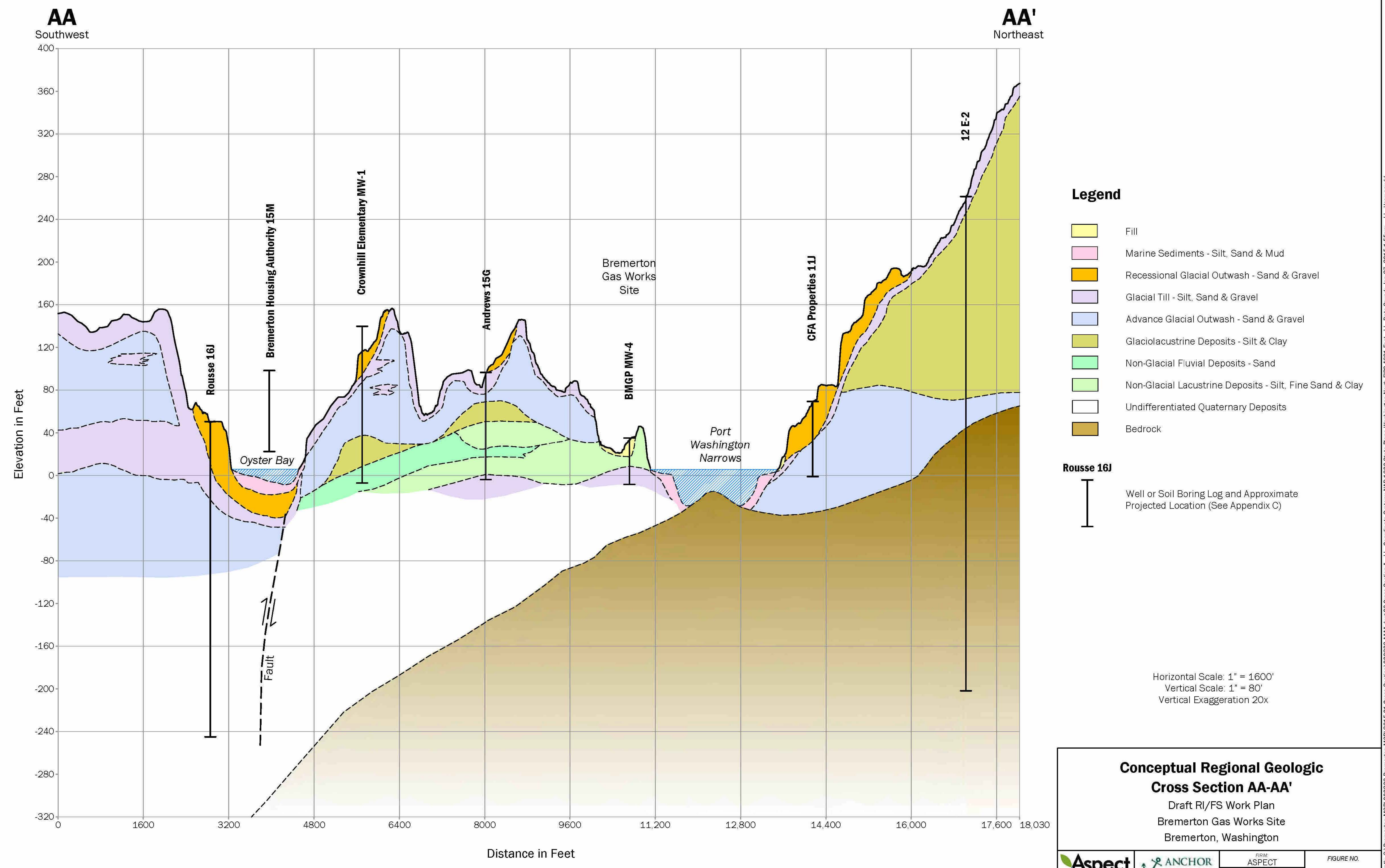
0 2,000 4,000
Feet
1:24,000

Surficial Geology and Regional Cross Section Location

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: CB/HRL/SCC | FIGURE NO. 2-6

GIS Path: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\2-6 Surficial Geology and Regional Cross Section Location.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/15/2015 || User: randrusyszyn || Print Date: 1/15/2015



Conceptual Regional Geologic Cross Section AA-AA'

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: SCC | FIGURE NO. 2-7

CAD Path: Q:\Bremerton MGP\080239 Bremerton MGP\2015-01 Cross Section\080239-AAAA.dwg 03-Cross Section A || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jan 27, 2015 1:55pm || User: scudd

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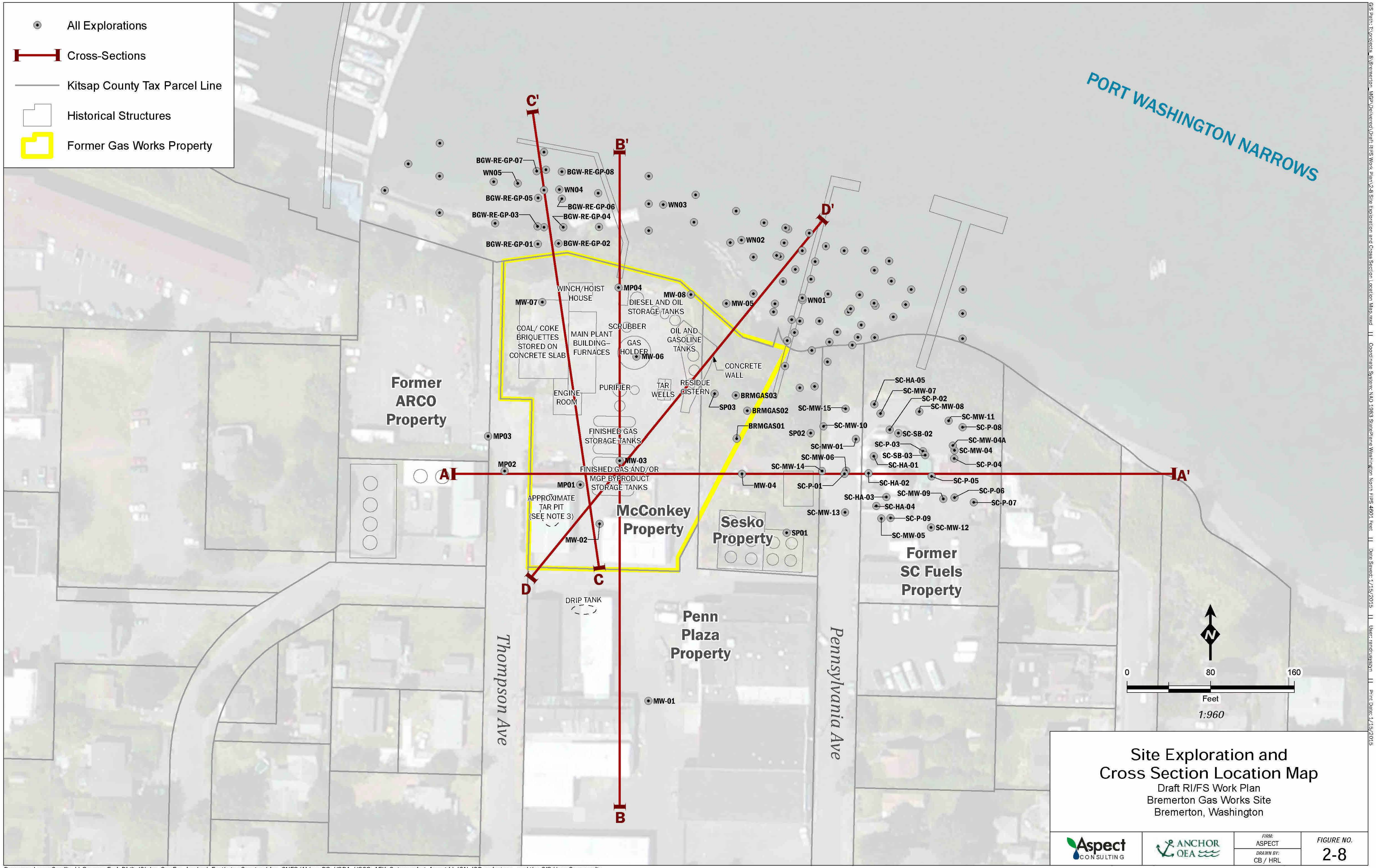

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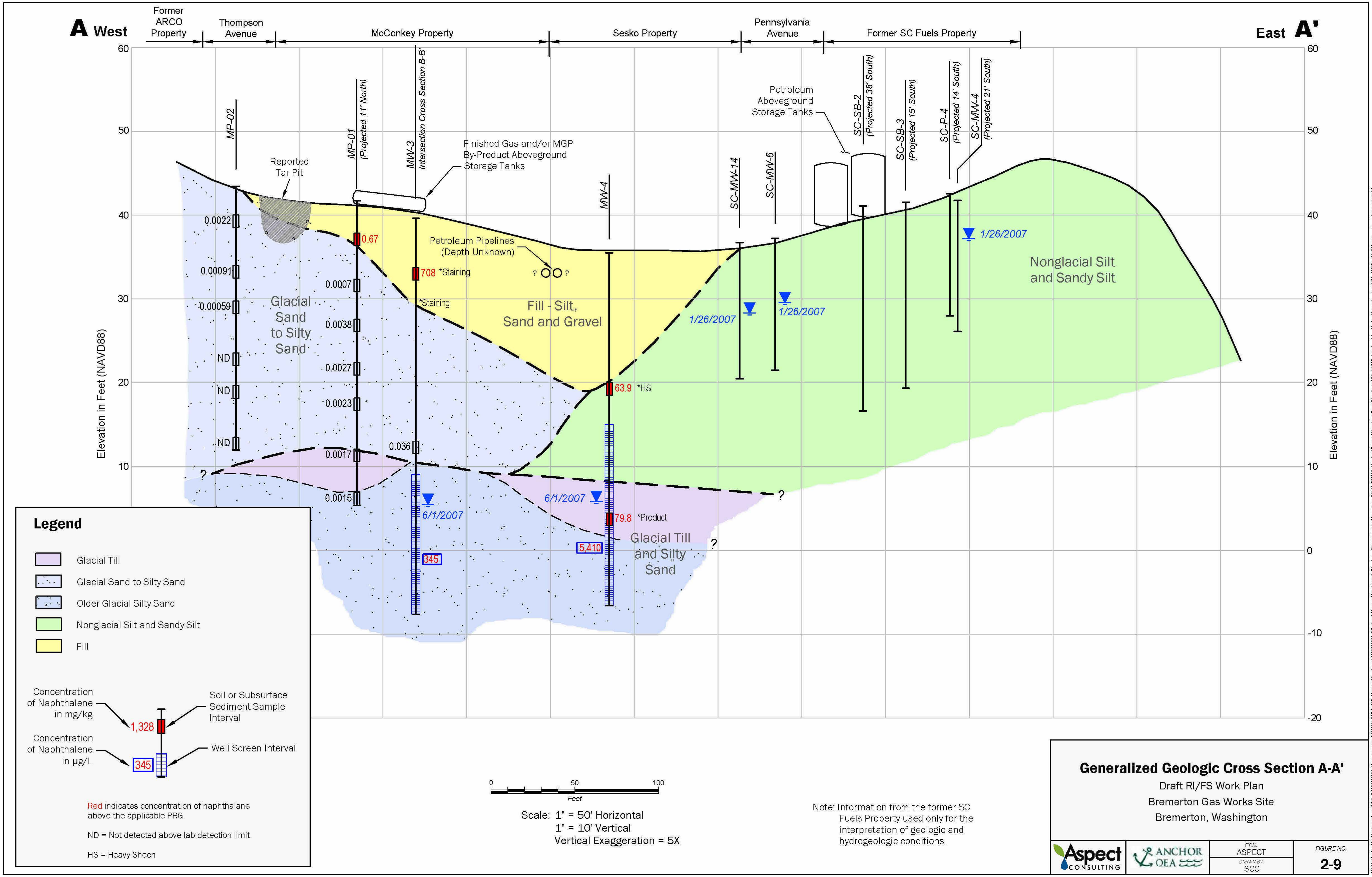
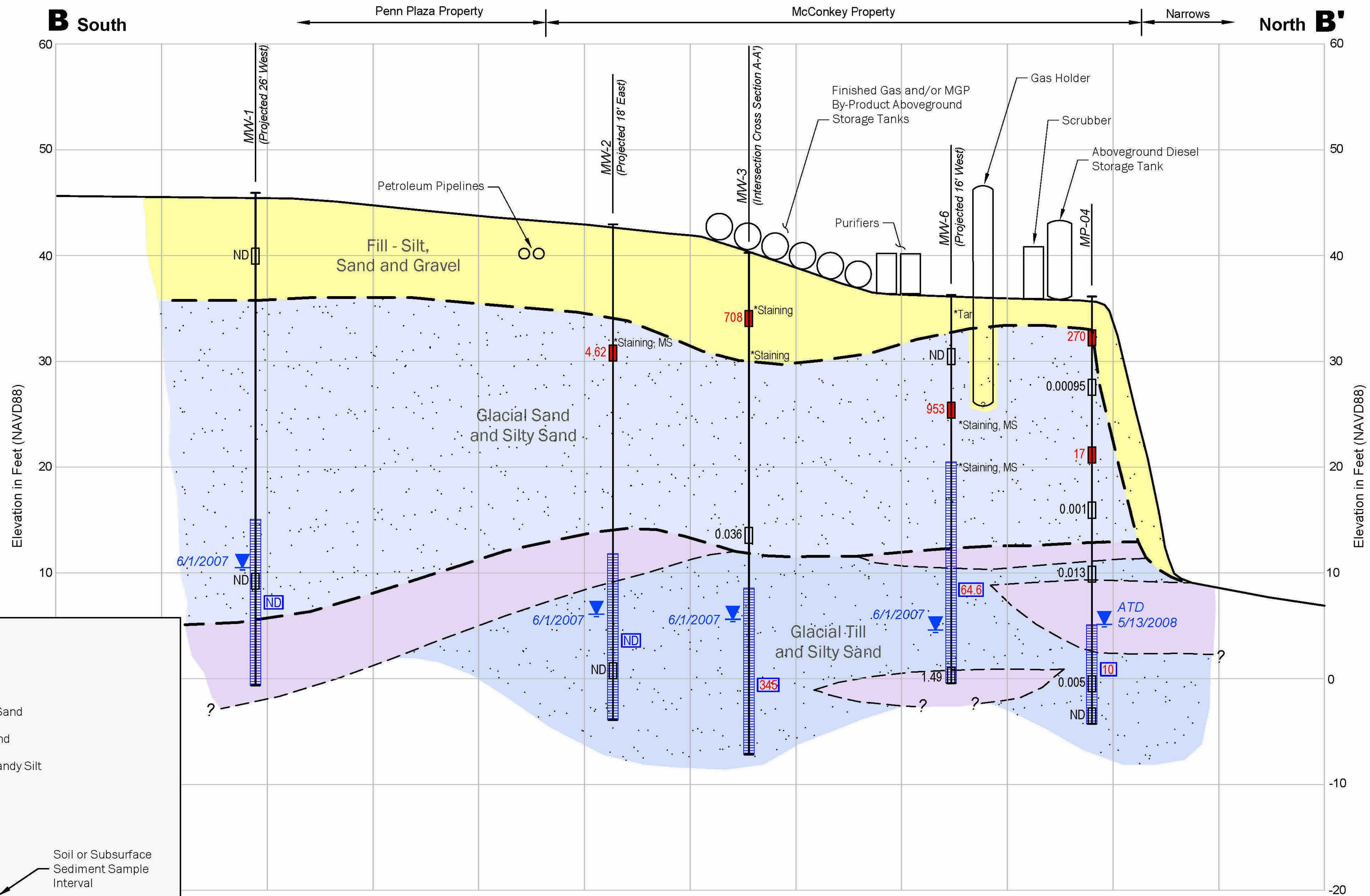


Generalized Geologic Cross Section A-A'

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect Consulting | Anchor QEA | FIRM: ASPECT | DRAWN BY: SCC | FIGURE NO. 2-9



Legend

- Glacial Till
- Glacial Sand to Silty Sand
- Older Glacial Silty Sand
- Nonglacial Silt and Sandy Silt
- Fill

Concentration of Naphthalene in mg/kg — 1,328 — Soil or Subsurface Sediment Sample Interval

Concentration of Naphthalene in µg/L — 345 — Well Screen Interval

Red indicates concentration of naphthalane above the applicable PRG.

ND = Not detected above lab detection limit.

MS = Medium Sheen

0 50 100
Feet

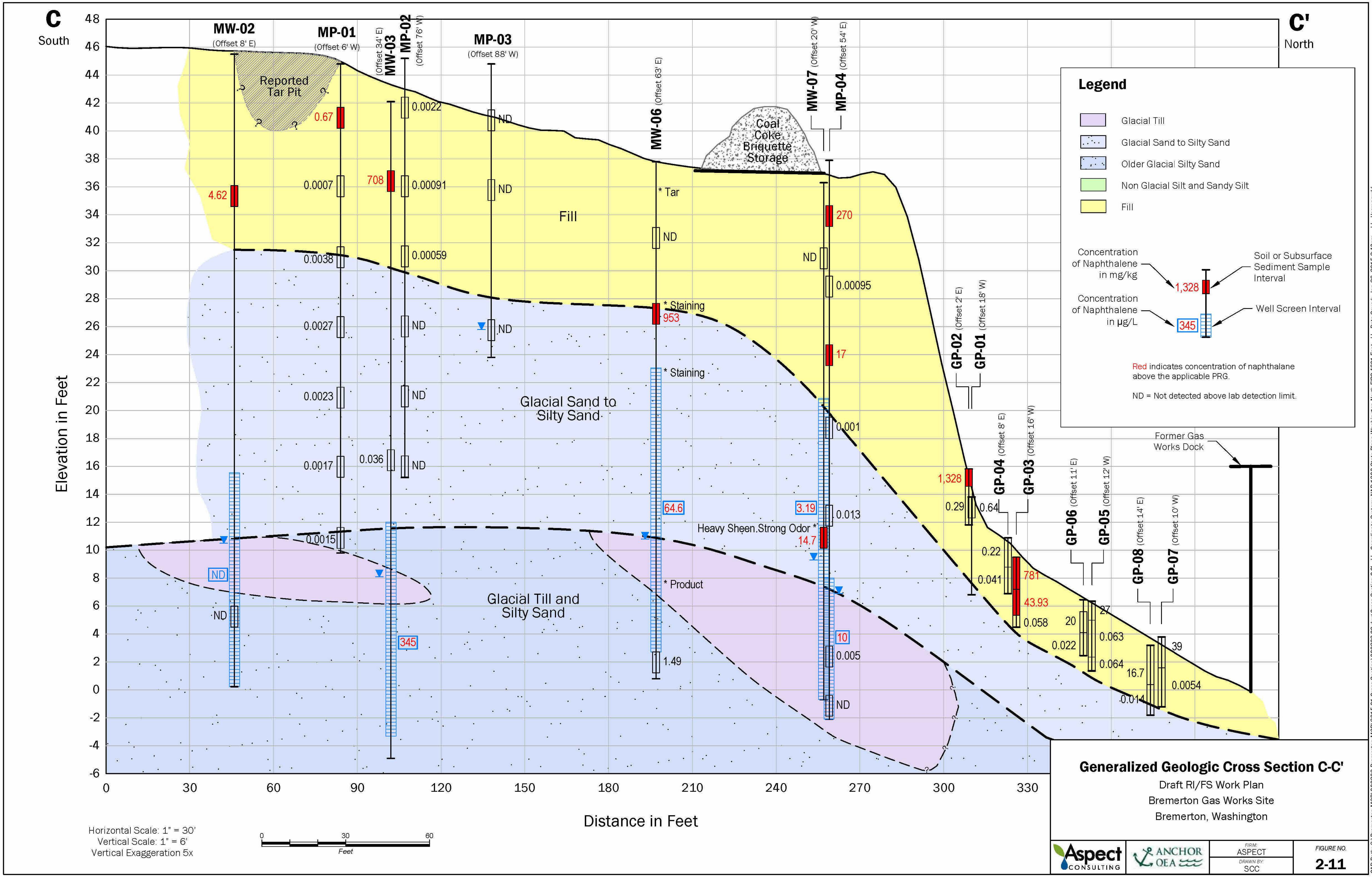
Scale: 1" = 50' Horiz
1" = 10' Vert
Vertical Exaggeration = 5X

Generalized Geologic Cross Section B-B'

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: PMB/SCC | FIGURE NO. 2-10

CAD Path: Q:\Bremerton MGP\080239 Bremerton MGP\2015-01 Cross Section\080239-BB.dwg Cross Section B-B' || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Jan 26, 2015 2:40pm || User: scudd



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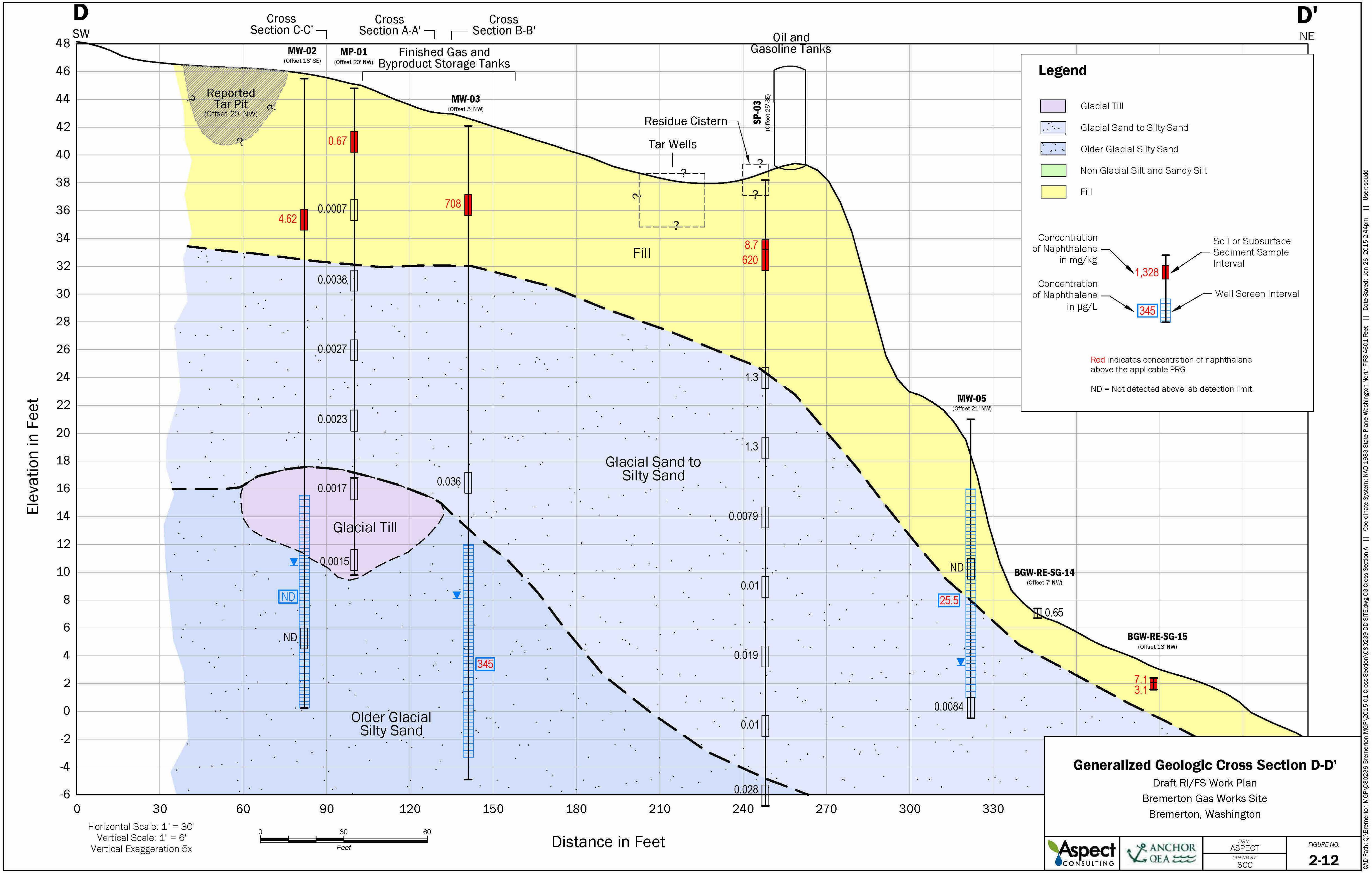

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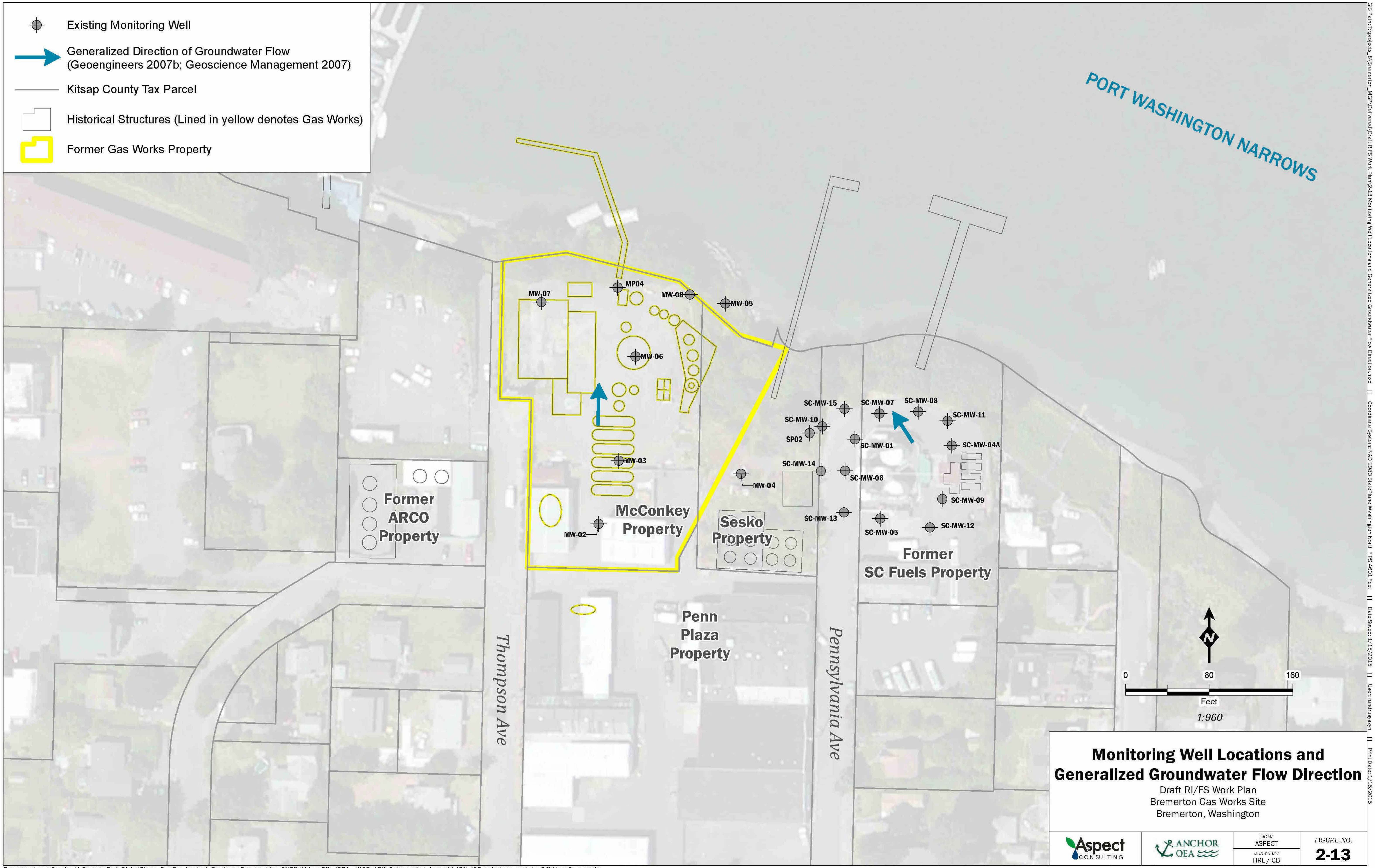

Monitoring Well Locations and Generalized Groundwater Flow Direction

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: HRL / CB | FIGURE NO. 2-13

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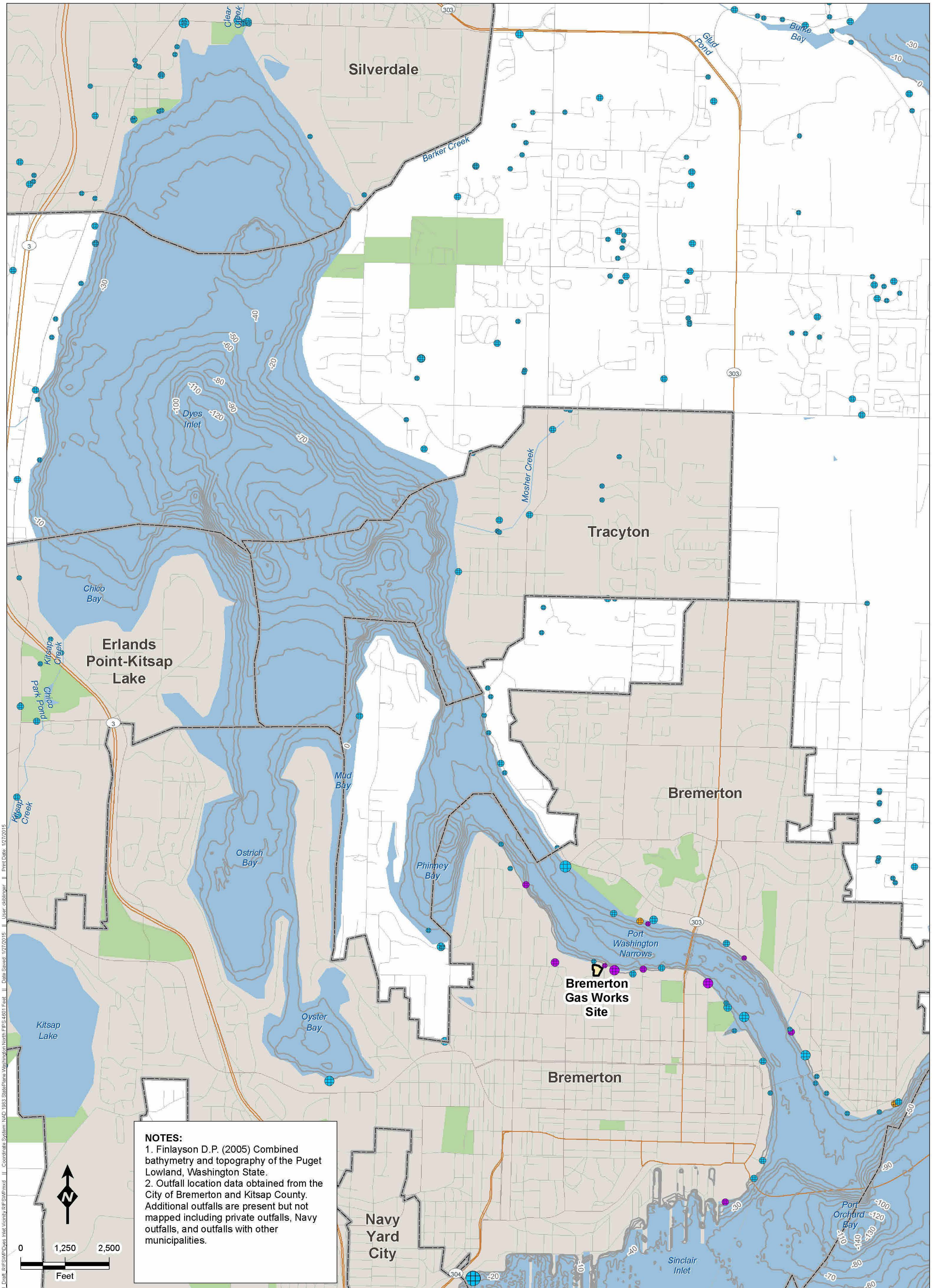


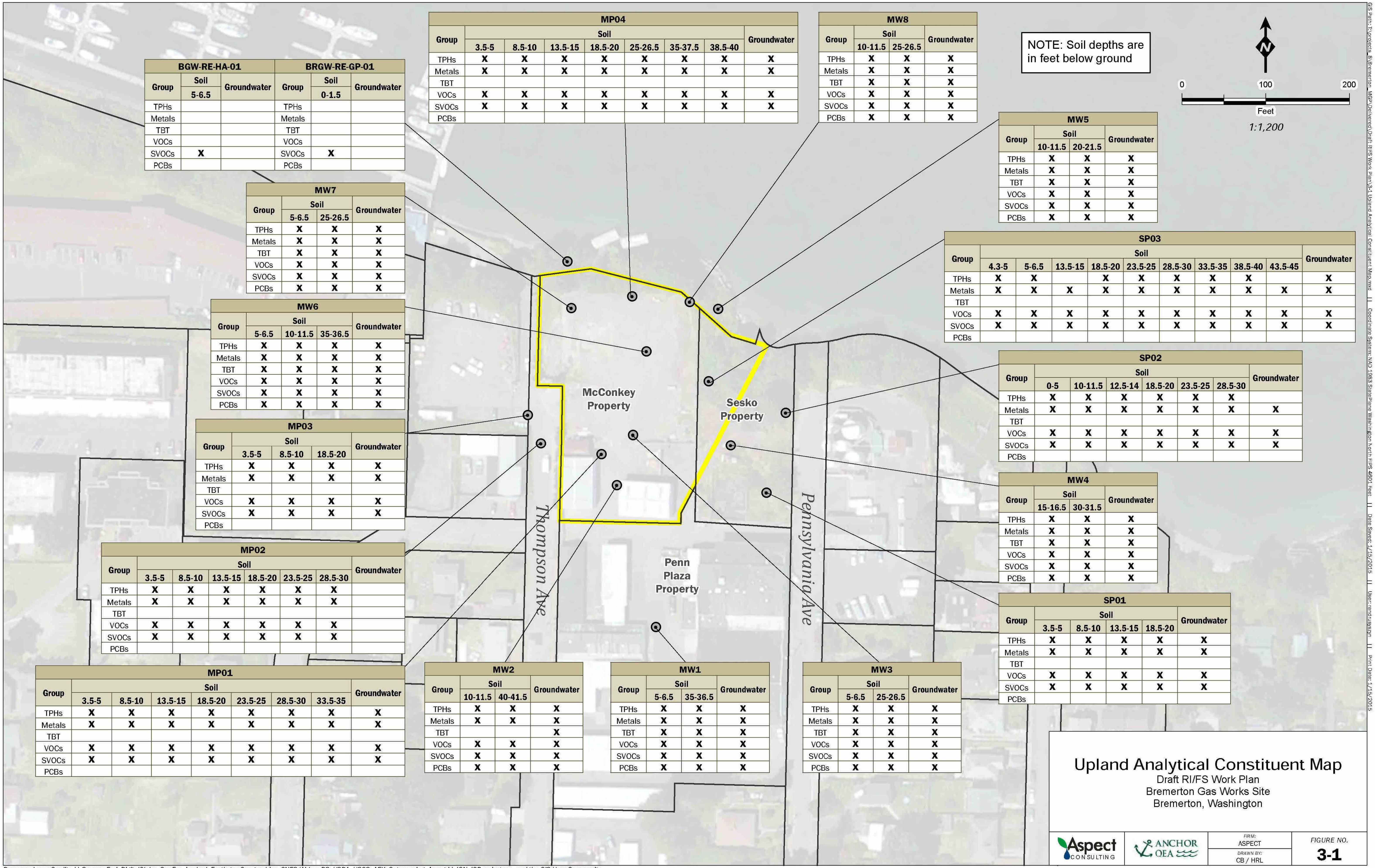
Interstates
Highways
PSDEM 2005 10-foot Contours[1]
Parks
Bremerton Gas Works Site
Cities
Unincorporated Areas
City Limits

Outfall Type[2]
Combined Storm Drain/CSO Outfall
CSO Outfall
Storm Drain

Outfall Size (inches)
8 - 12
13 - 24
25 - 36
37 - 48
49 - 60
61 - 72
73 - 84

Dyes Inlet and Port Washington Narrows Bathymetry and Outfall Locations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR QEA | DRAWN BY: ckiblinger | FIGURE NO. **2-14**



BGW-RE-HA-01		
Group	Soil 5-6.5	Groundwater
TPHs		
Metals		
TBT		
VOCs		
SVOCs	X	
PCBs		

BRGW-RE-GP-01		
Group	Soil 0-1.5	Groundwater
TPHs		
Metals		
TBT		
VOCs		
SVOCs	X	
PCBs		

MP04								
Group	Soil							Groundwater
	3.5-5	8.5-10	13.5-15	18.5-20	25-26.5	35-37.5	38.5-40	
TPHs	X	X	X	X	X	X	X	X
Metals	X	X	X	X	X	X	X	X
TBT								
VOCs	X	X	X	X	X	X	X	X
SVOCs	X	X	X	X	X	X	X	X
PCBs								

MW8			
Group	Soil		Groundwater
	10-11.5	25-26.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

MW5			
Group	Soil		Groundwater
	10-11.5	20-21.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

MW7			
Group	Soil		Groundwater
	5-6.5	25-26.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

SP03										
Group	Soil									Groundwater
	4.3-5	5-6.5	13.5-15	18.5-20	23.5-25	28.5-30	33.5-35	38.5-40	43.5-45	
TPHs	X	X		X	X	X	X	X		X
Metals	X	X	X	X	X	X	X	X	X	X
TBT										
VOCs	X	X	X	X	X	X	X	X	X	X
SVOCs	X	X	X	X	X	X	X	X	X	X
PCBs										

MW6				
Group	Soil			Groundwater
	5-6.5	10-11.5	35-36.5	
TPHs	X	X	X	X
Metals	X	X	X	X
TBT	X	X	X	X
VOCs	X	X	X	X
SVOCs	X	X	X	X
PCBs	X	X	X	X

SP02							
Group	Soil						Groundwater
	0-5	10-11.5	12.5-14	18.5-20	23.5-25	28.5-30	
TPHs	X	X	X	X	X	X	
Metals	X	X	X	X	X	X	X
TBT							
VOCs	X	X	X	X	X	X	X
SVOCs	X	X	X	X	X	X	X
PCBs							

MP03				
Group	Soil			Groundwater
	3.5-5	8.5-10	18.5-20	
TPHs	X	X	X	X
Metals	X	X	X	X
TBT				
VOCs	X	X	X	X
SVOCs	X	X	X	X
PCBs				

MW4			
Group	Soil		Groundwater
	15-16.5	30-31.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

MP02							
Group	Soil						Groundwater
	3.5-5	8.5-10	13.5-15	18.5-20	23.5-25	28.5-30	
TPHs	X	X	X	X	X	X	
Metals	X	X	X	X	X	X	
TBT							
VOCs	X	X	X	X	X	X	
SVOCs	X	X	X	X	X	X	
PCBs							

SP01					
Group	Soil				Groundwater
	3.5-5	8.5-10	13.5-15	18.5-20	
TPHs	X	X	X	X	X
Metals	X	X	X	X	X
TBT					
VOCs	X	X	X	X	X
SVOCs	X	X	X	X	X
PCBs					

MP01								
Group	Soil							Groundwater
	3.5-5	8.5-10	13.5-15	18.5-20	23.5-25	28.5-30	33.5-35	
TPHs	X	X	X	X	X	X	X	X
Metals	X	X	X	X	X	X	X	X
TBT								
VOCs	X	X	X	X	X	X	X	X
SVOCs	X	X	X	X	X	X	X	X
PCBs								

MW2			
Group	Soil		Groundwater
	10-11.5	40-41.5	
TPHs	X	X	X
Metals	X	X	X
TBT			X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

MW1			
Group	Soil		Groundwater
	5-6.5	35-36.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

MW3			
Group	Soil		Groundwater
	5-6.5	25-26.5	
TPHs	X	X	X
Metals	X	X	X
TBT	X	X	X
VOCs	X	X	X
SVOCs	X	X	X
PCBs	X	X	X

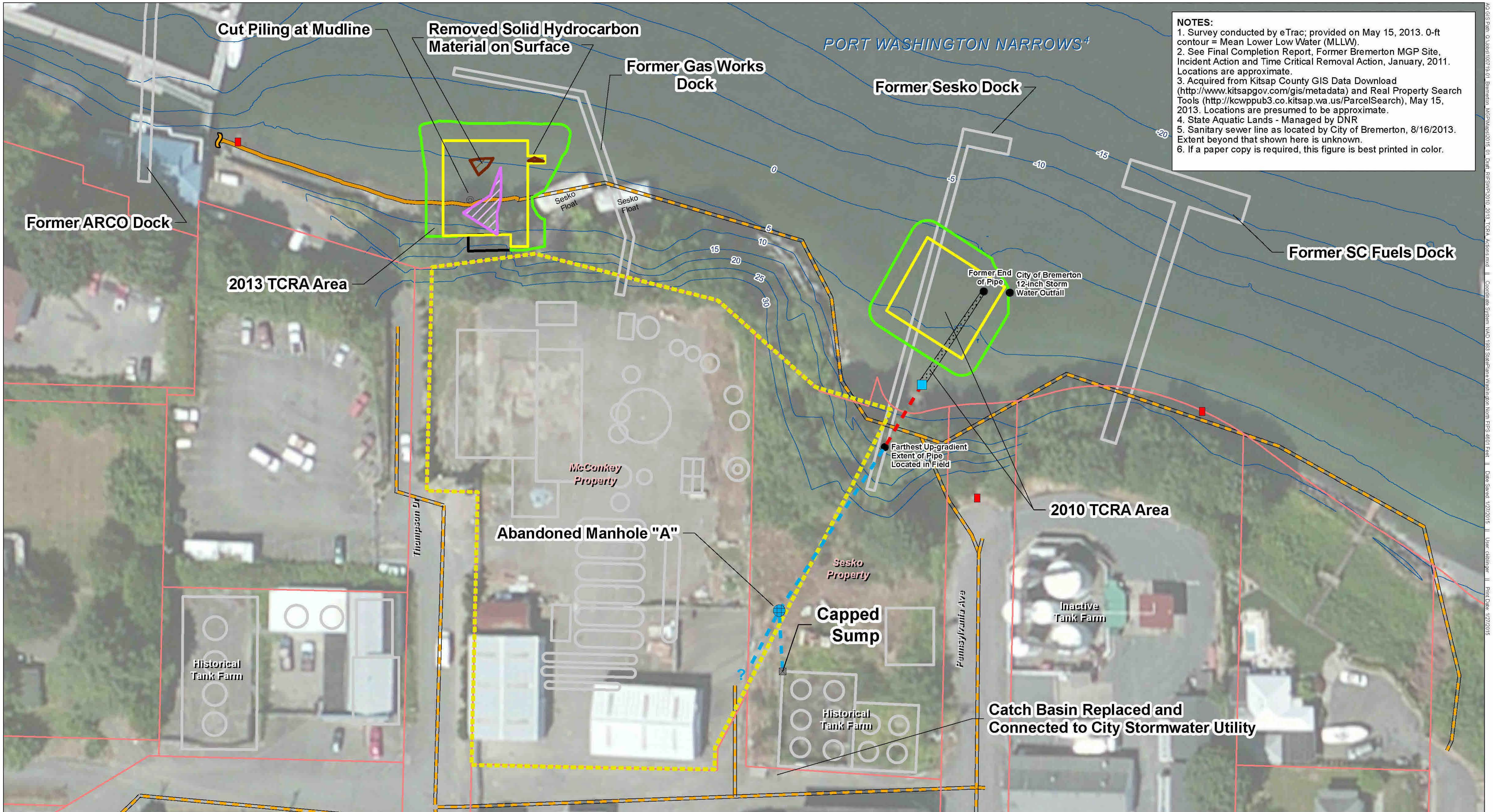
Upland Analytical Constituent Map

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: CB / HRL | FIGURE NO. **3-1**

GIS Path: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\3-1 Upland Analytical Constituent Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/15/2015 || User: randrussyan || Print Date: 1/15/2015

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



NOTES:
1. Survey conducted by eTrac; provided on May 15, 2013. 0-ft contour = Mean Lower Low Water (MLLW).
2. See Final Completion Report, Former Bremerton MGP Site, Incident Action and Time Critical Removal Action, January, 2011. Locations are approximate.
3. Acquired from Kitsap County GIS Data Download (http://www.kitsapgov.com/gis/metadata) and Real Property Search Tools (http://kcwppub3.co.kitsap.wa.us/ParcelSearch), May 15, 2013. Locations are presumed to be approximate.
4. State Aquatic Lands - Managed by DNR
5. Sanitary sewer line as located by City of Bremerton, 8/16/2013. Extent beyond that shown here is unknown.
6. If a paper copy is required, this figure is best printed in color.

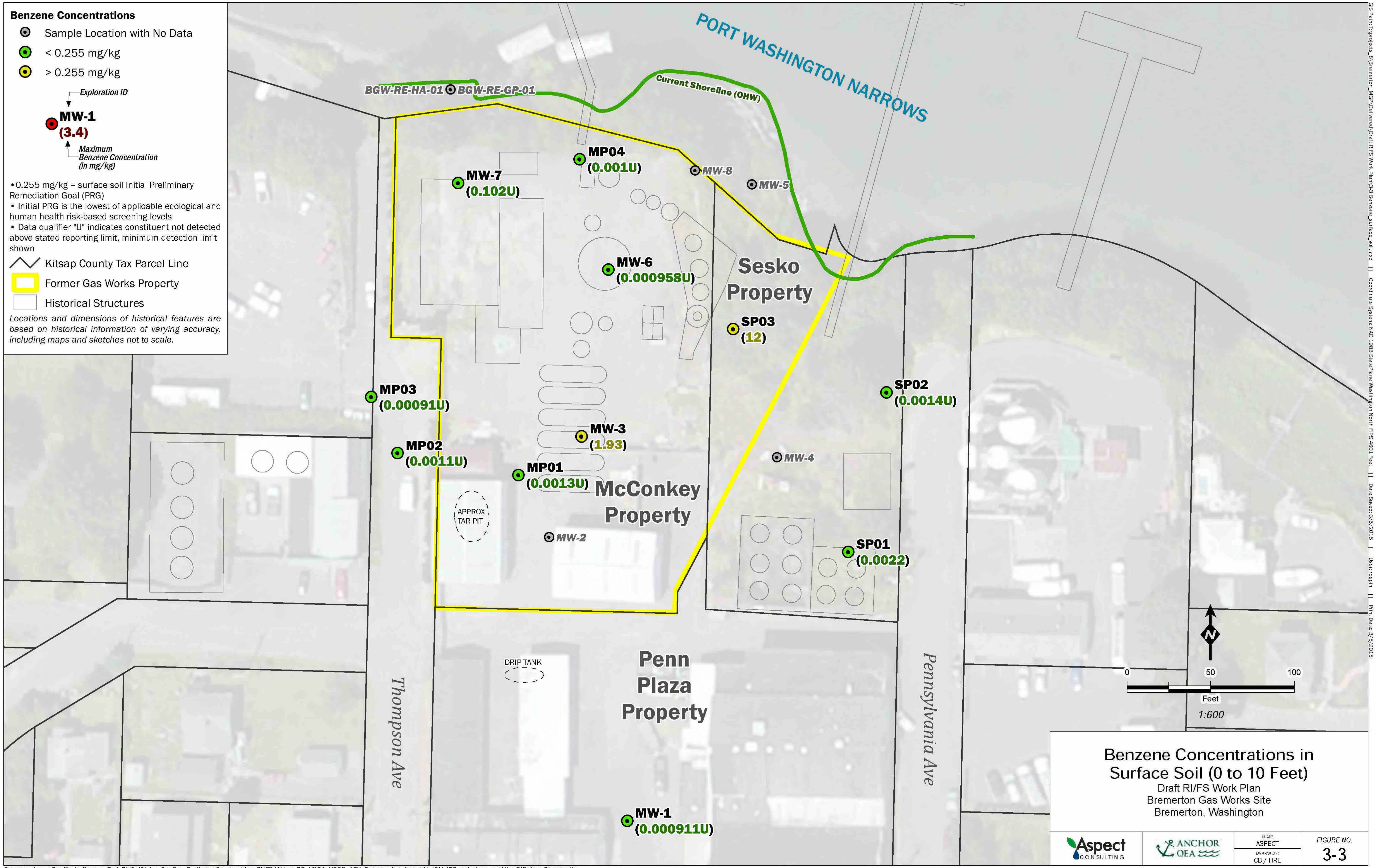
Approximate Public Notice Sign Location
Field-located Sanitary Sewer Line[5]
Sanitary Sewer *(Not Field Located)*
Sewer Line Continues West from this Location
2010 TCRA/IA Pipe Plug Location[2]
Remaining 12-inch Concrete Pipe[2]
Field Verified Pipe Location
Capped Sump
Area of Observed Hydrocarbon-like Sheen
Solid Hydrocarbon-like Material
Historical Structures
Former Gas Works Property
Approximate Reactive Core Mat Cover Areas
Approximate Reactive Core Mat Areas
Pipe Removed and Backfilled to Grade[2]
Parcel Boundaries[3]
Storm Sewer *(Not Field Located)*
Bathymetry/Topography Contours (MLLW ft)[1]

N

0 25 50
Feet
1:650

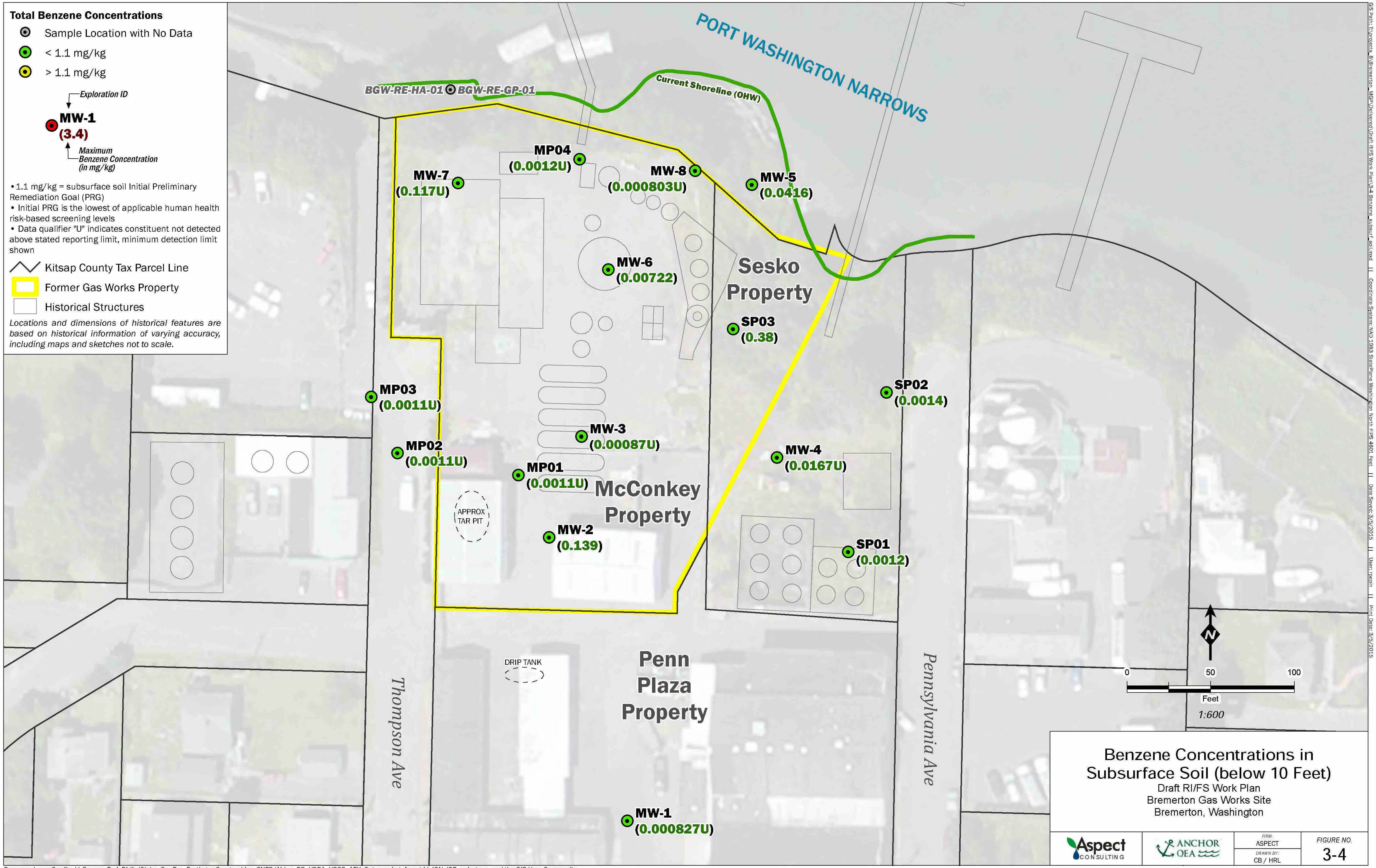
2010 and 2013 TCRA
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

FIRM: ANCHOR QEA
DRAWN BY: ckiblinger
FIGURE NO. **3-2**



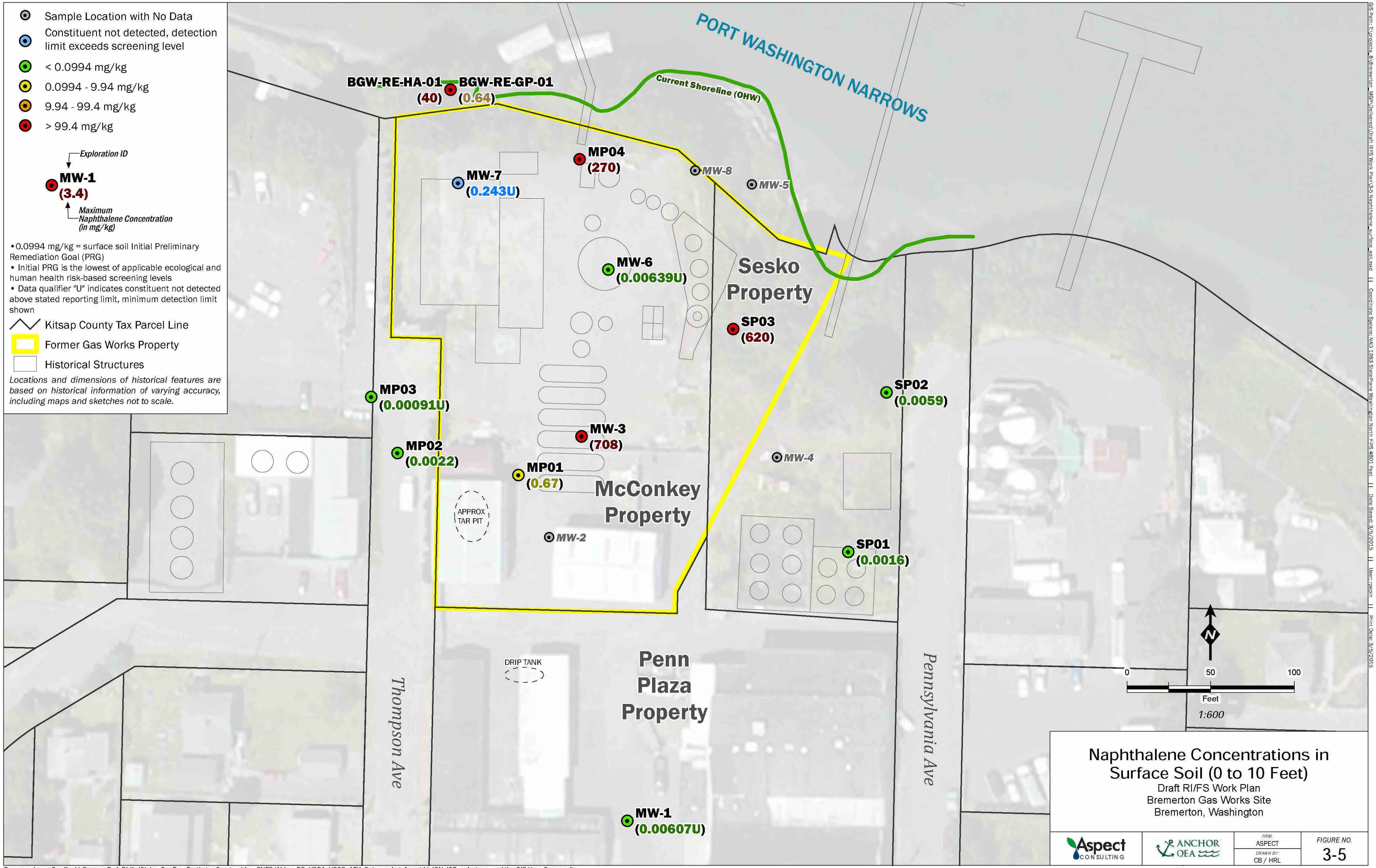
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

DNR-00040800

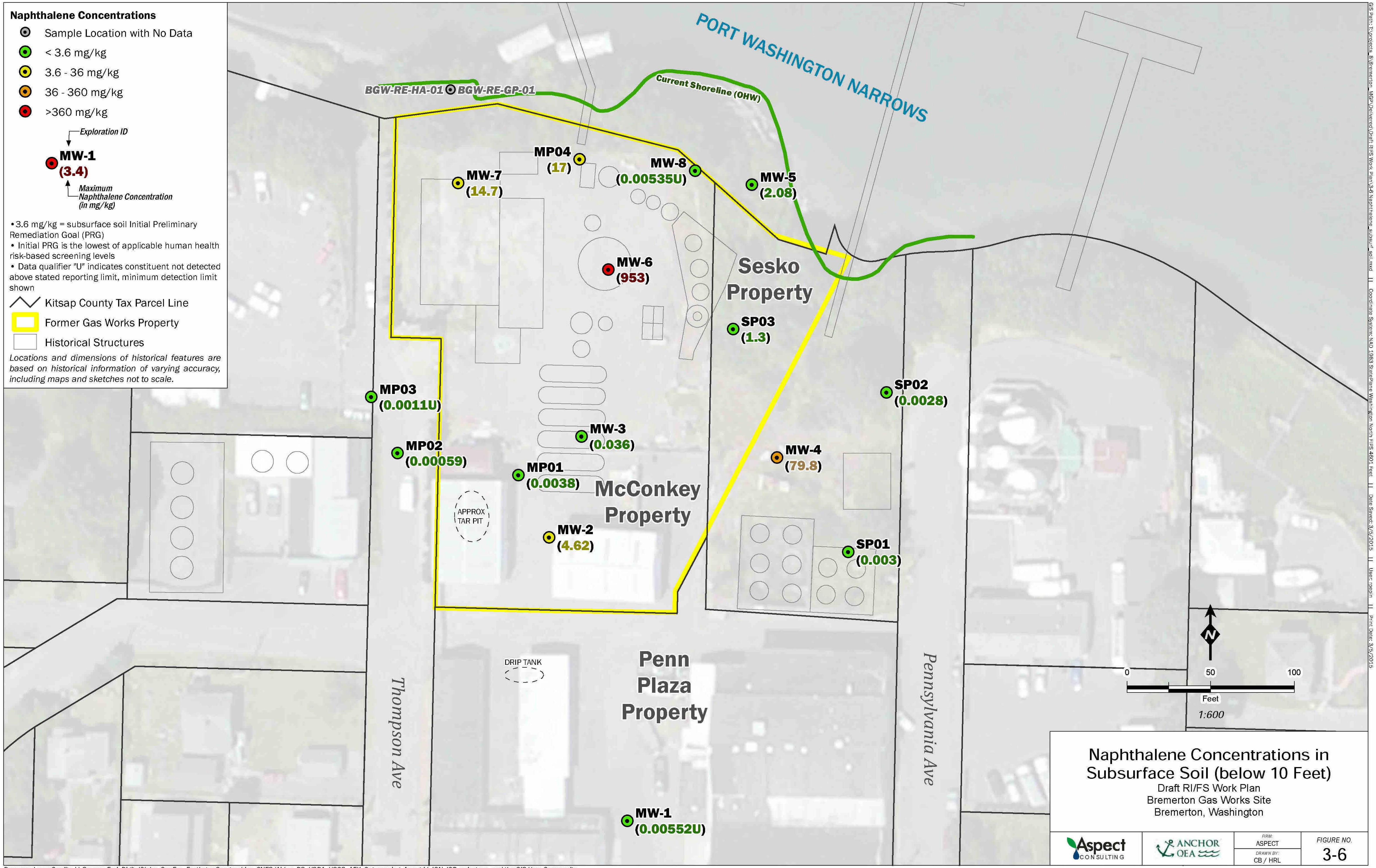


Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

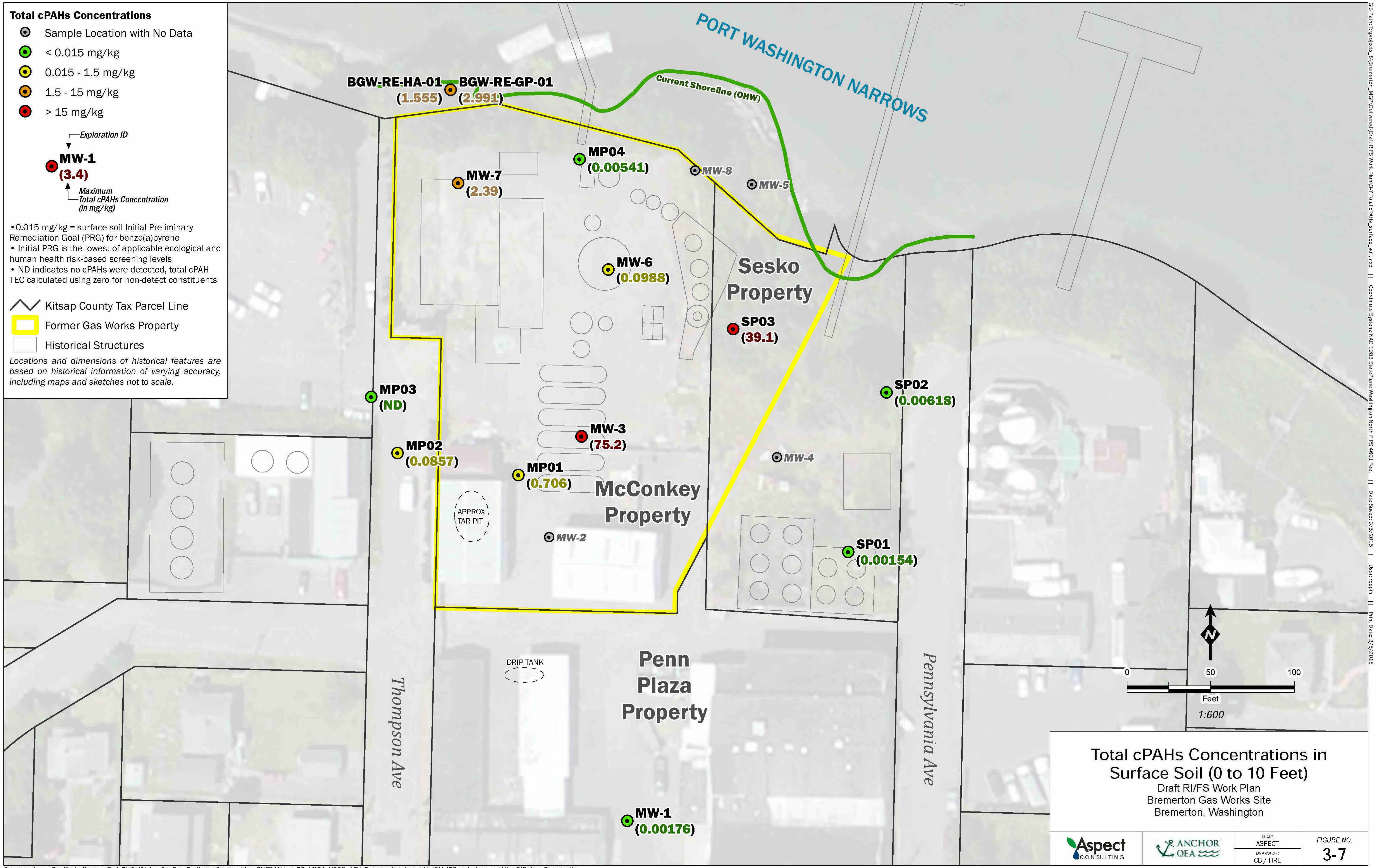
DNR-00040801



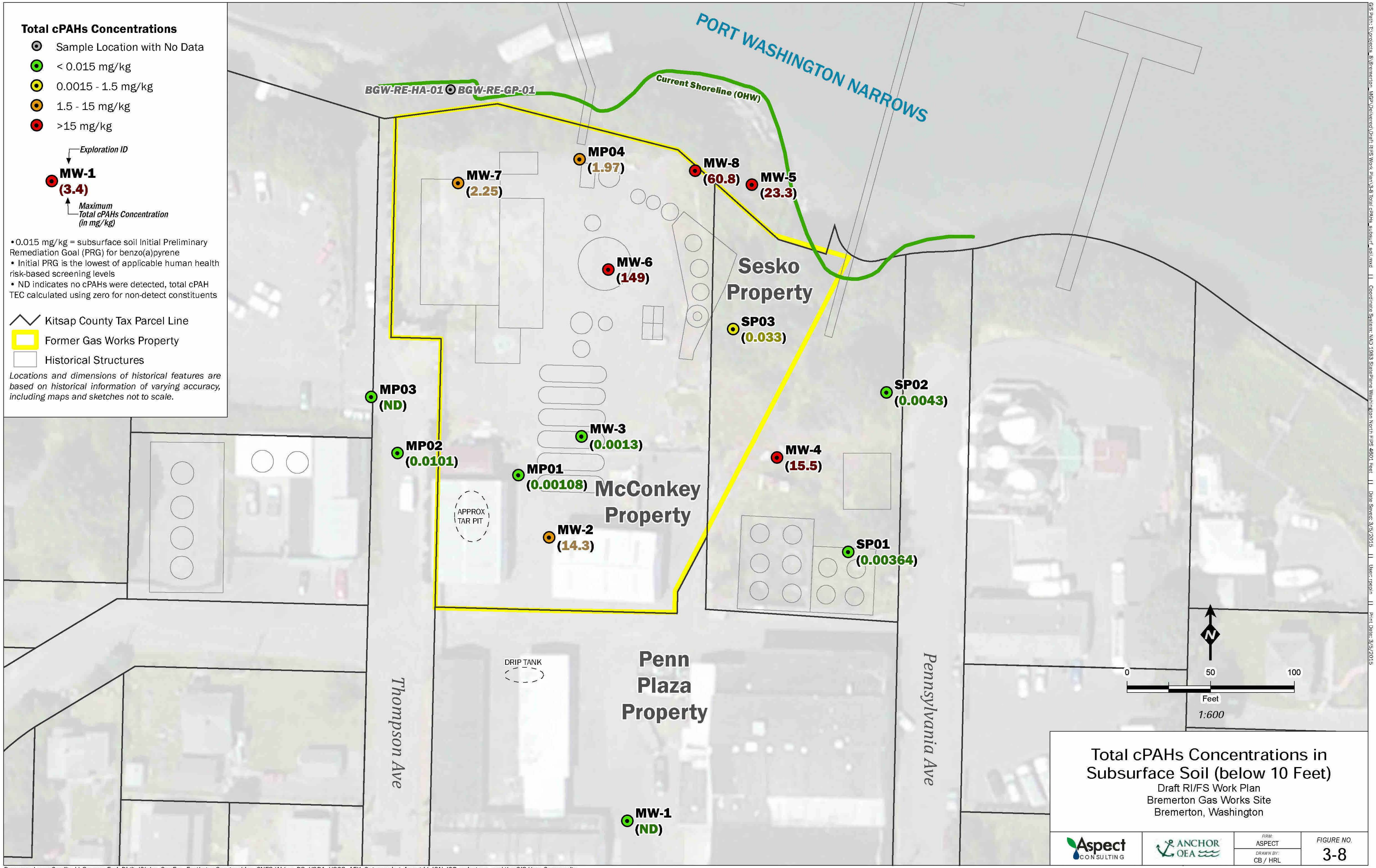
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

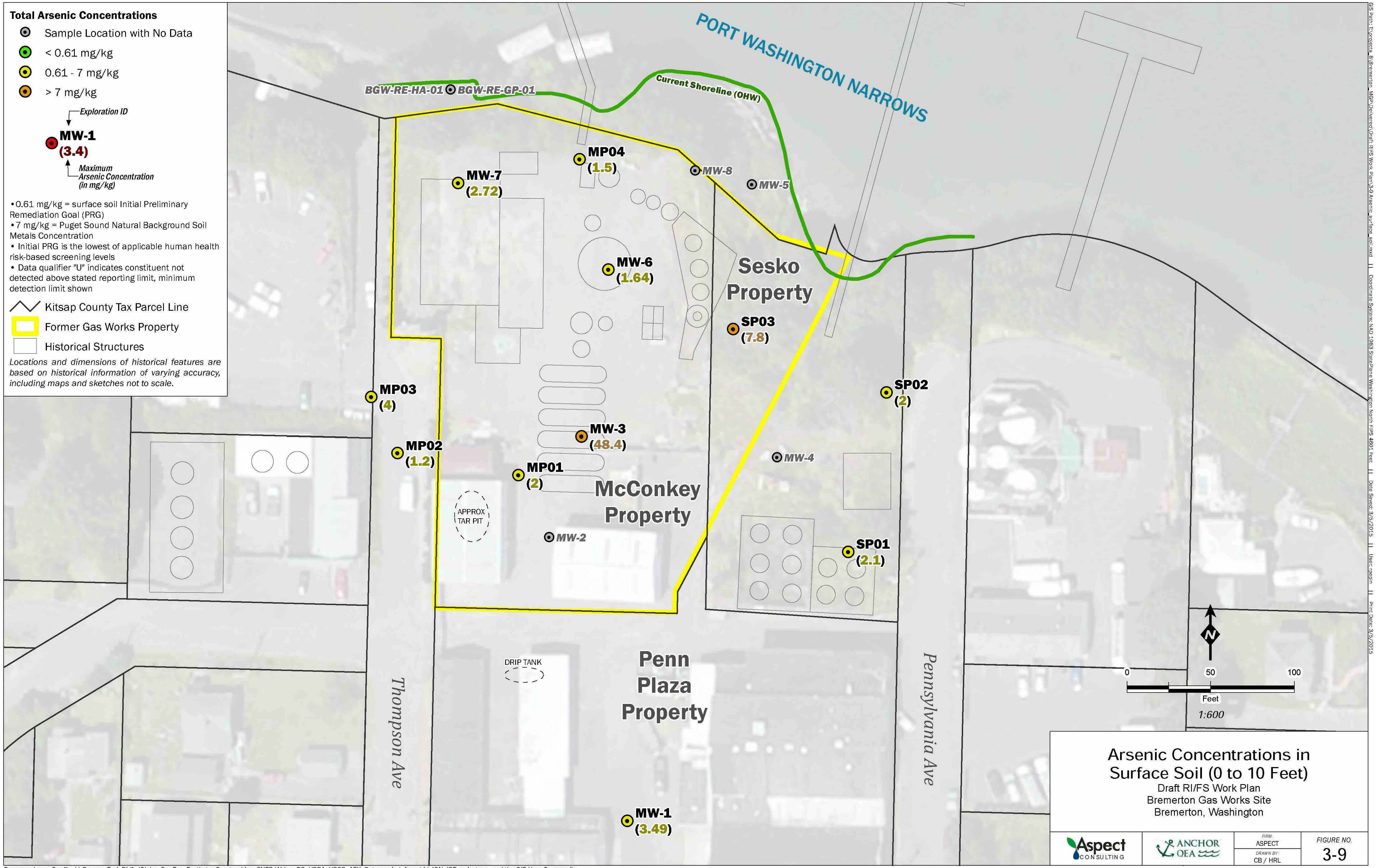


Total cPAHs Concentrations in Subsurface Soil (below 10 Feet)
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

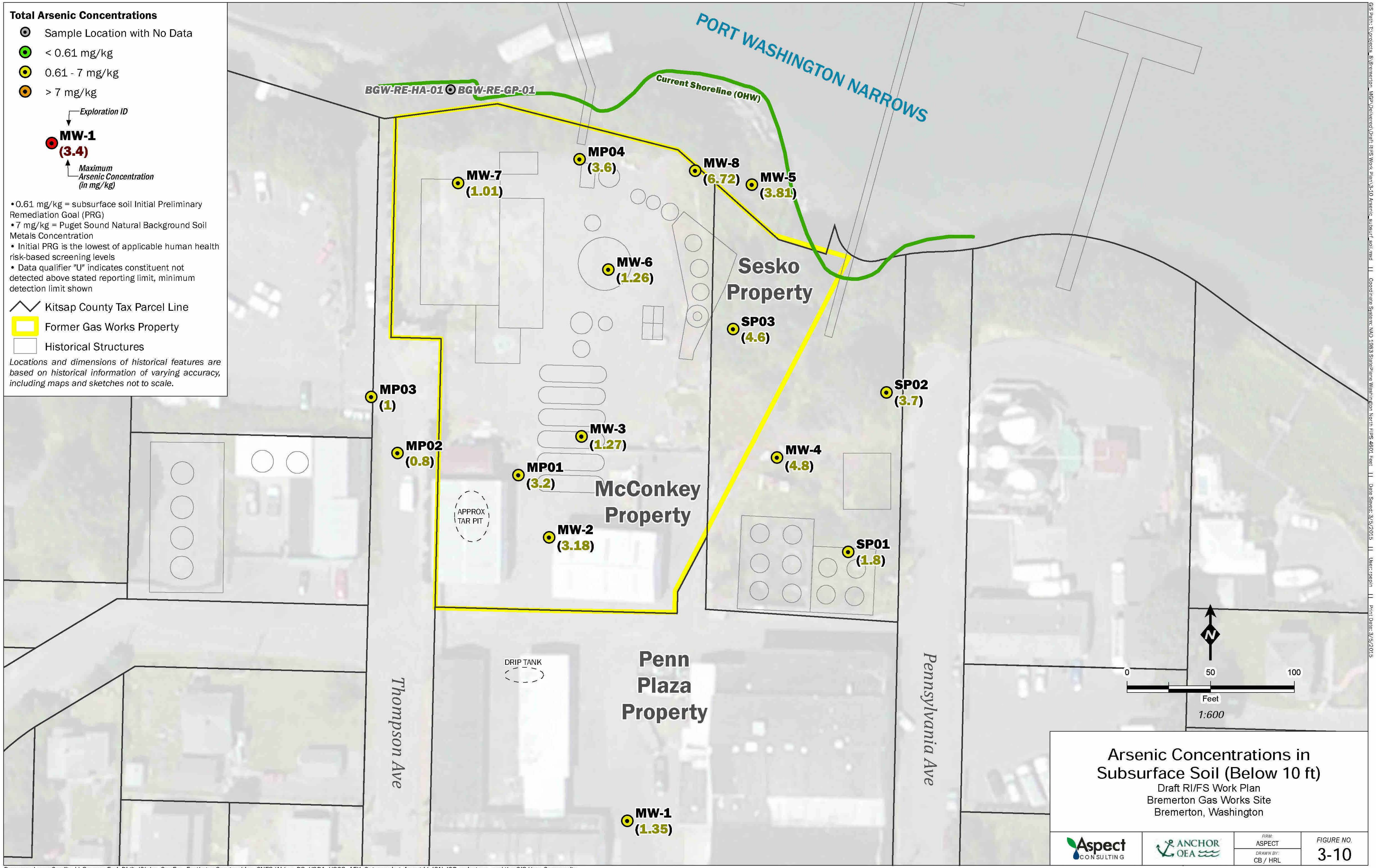
Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: CB / HRL | FIGURE NO. 3-8

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

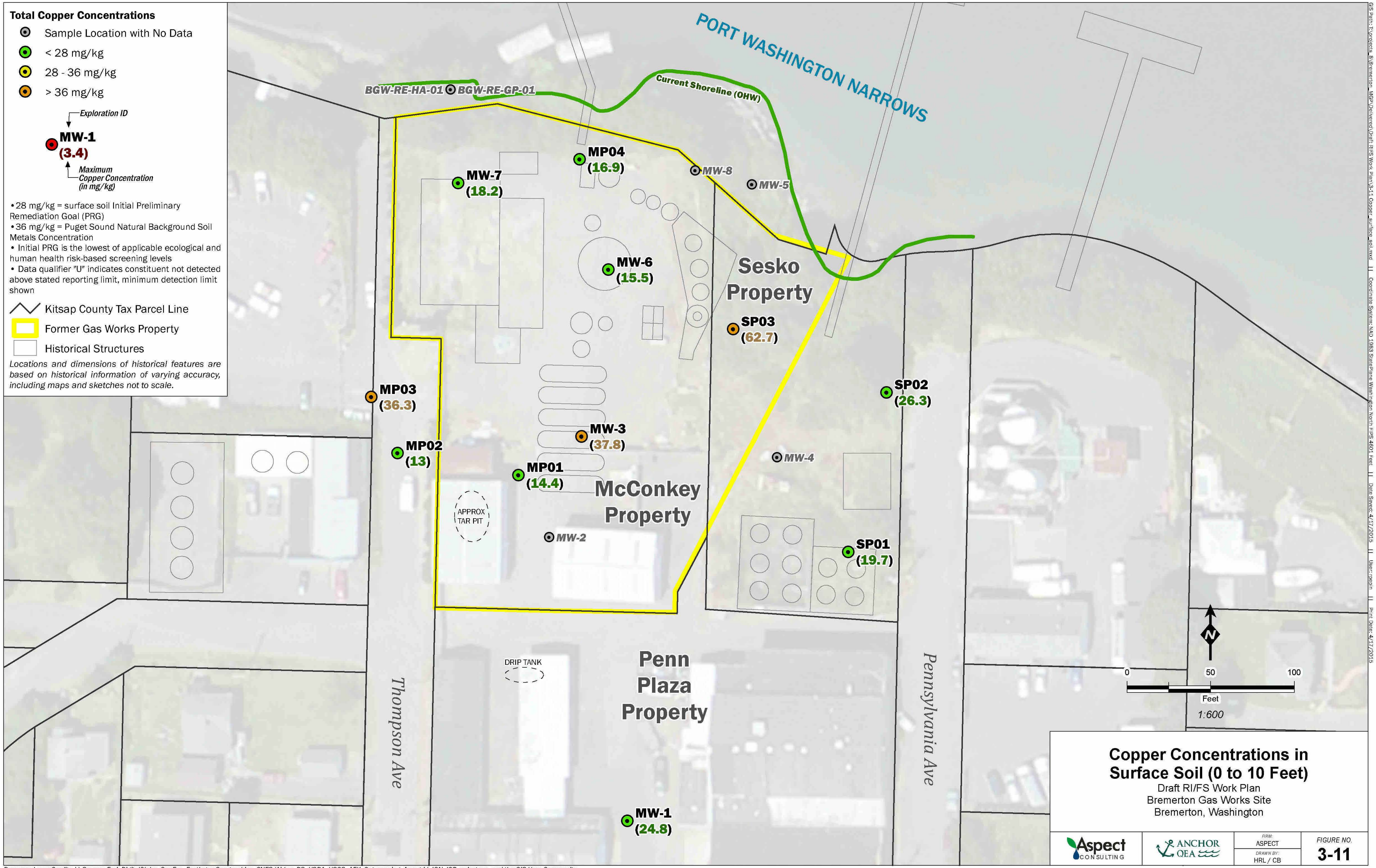
DNR-00040805



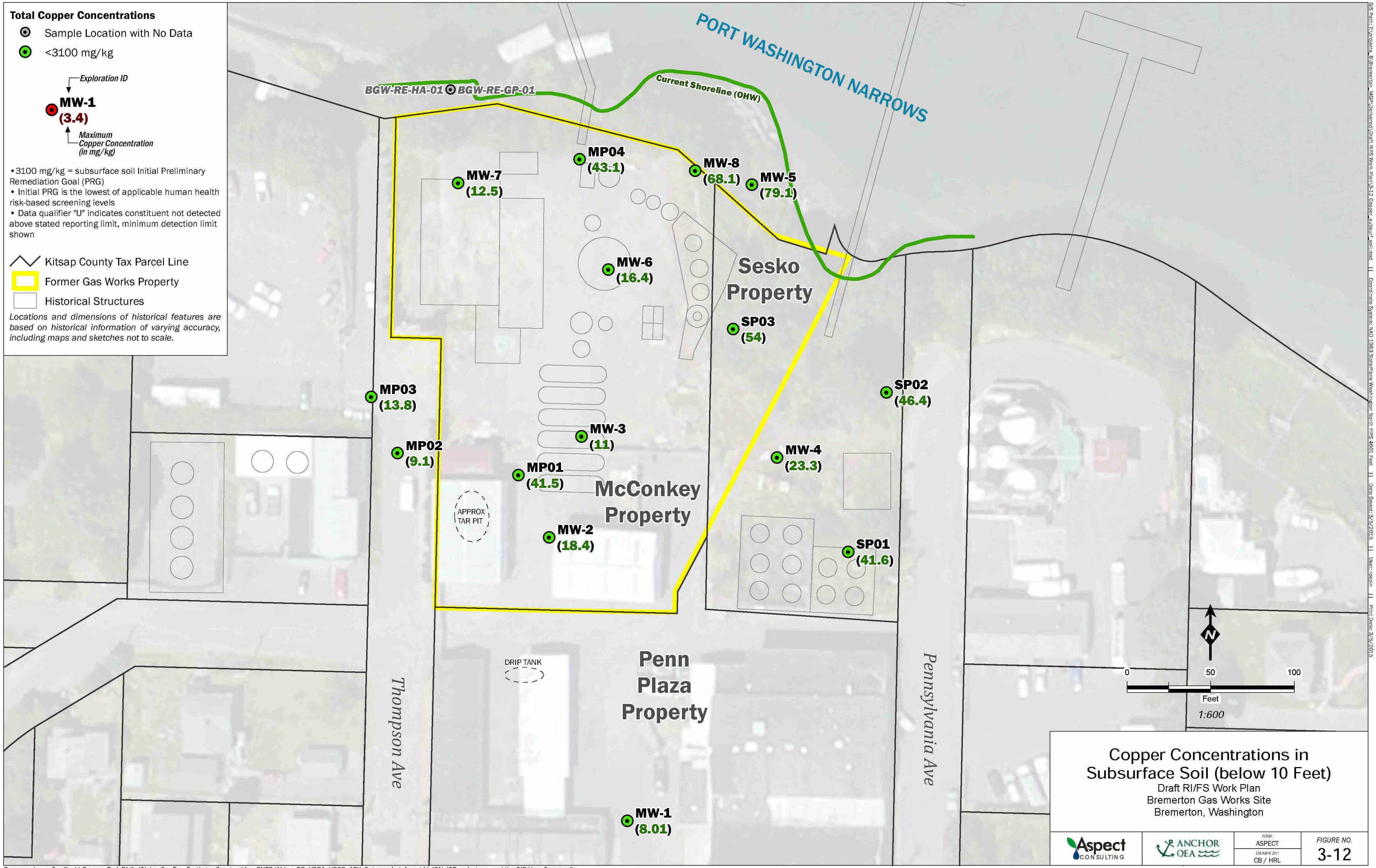
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

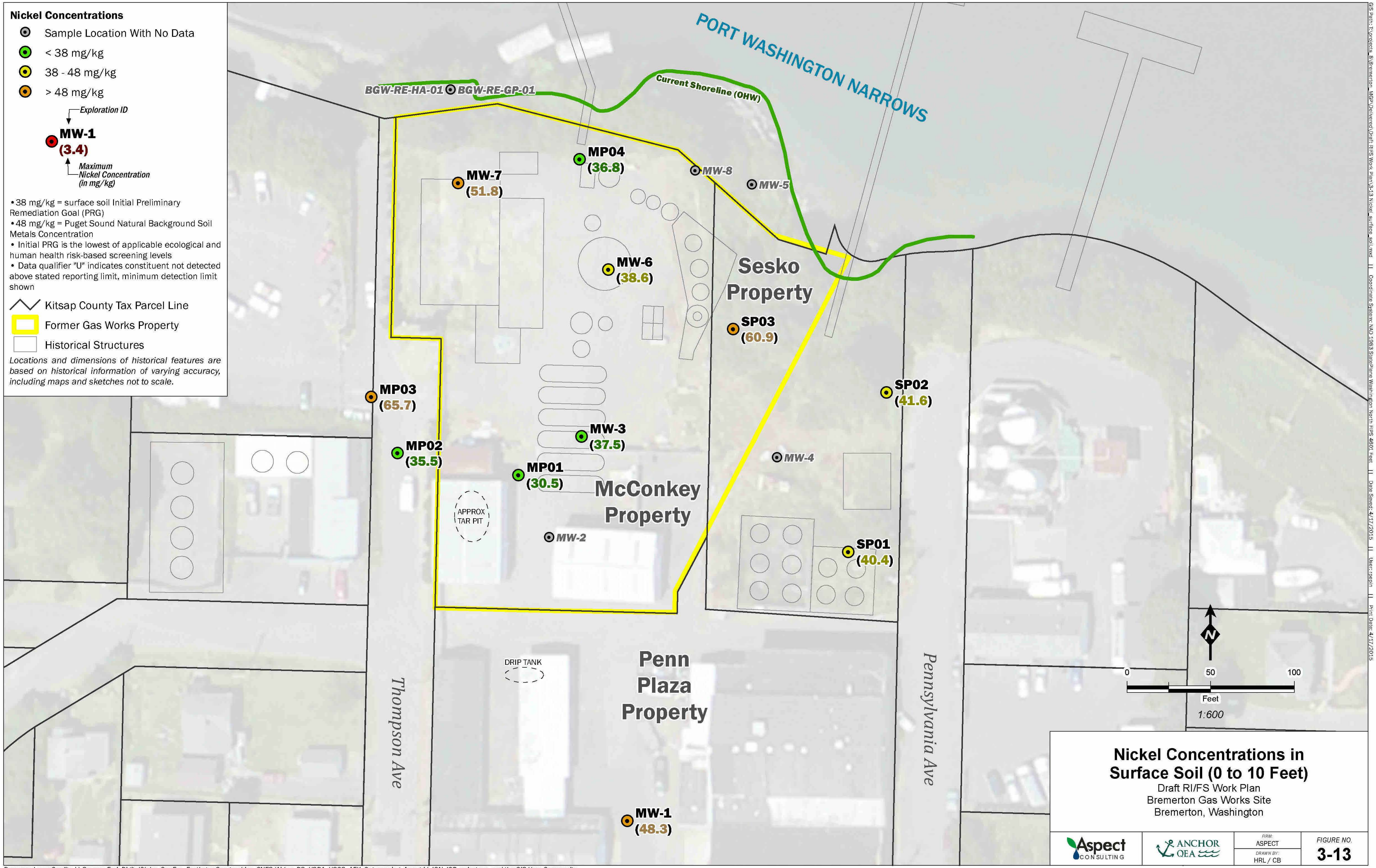


Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

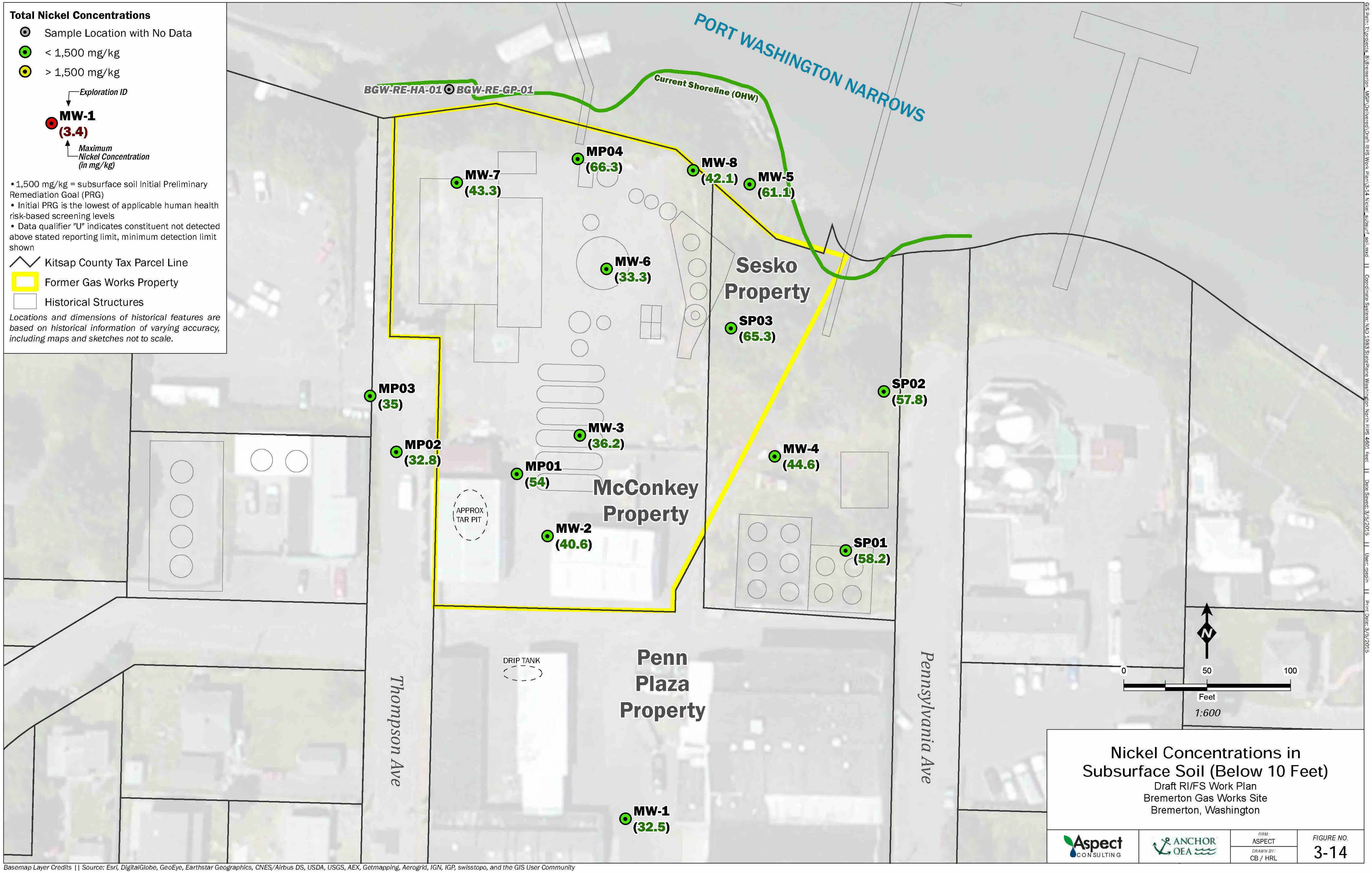


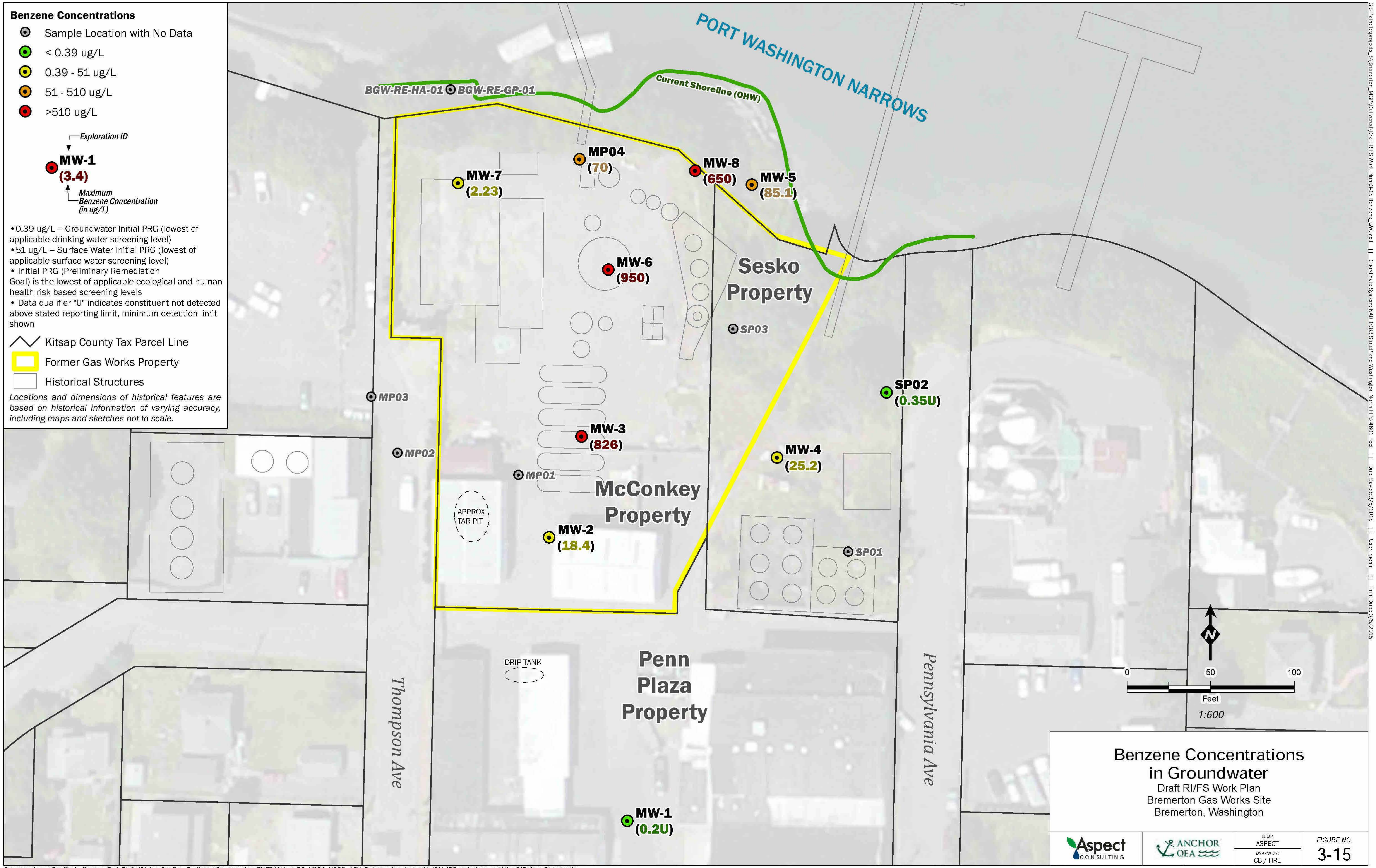
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

DNR-00040809

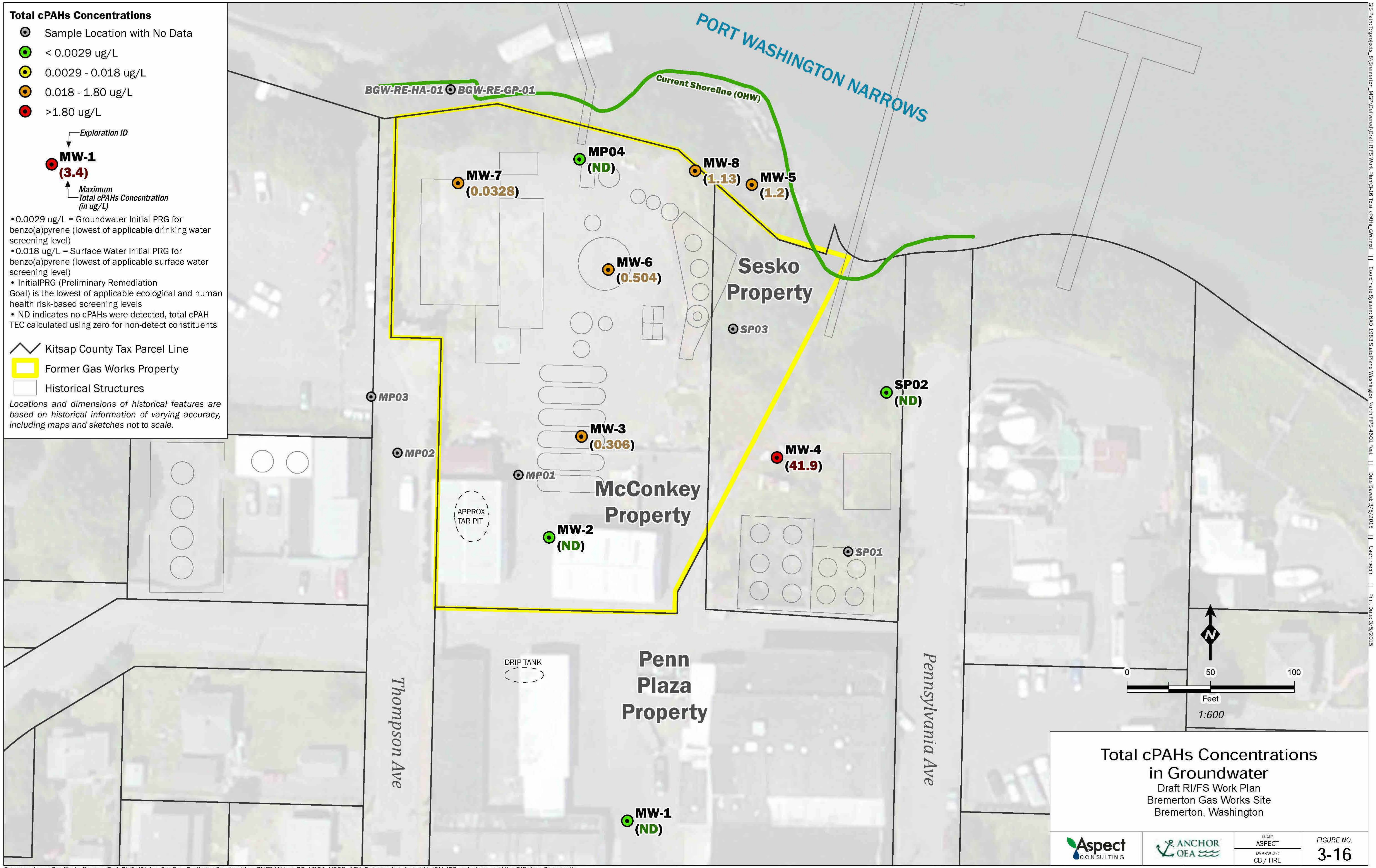


Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Total Nickel Concentrations
Sample Location with No Data
< 1,500 mg/kg
> 1,500 mg/kg
Exploration ID
MW-1
(3.4)
Maximum Nickel Concentration (in mg/kg)
•1,500 mg/kg = subsurface soil Initial Preliminary Remediation Goal (PRG)
• Initial PRG is the lowest of applicable human health risk-based screening levels
• Data qualifier "U" indicates constituent not detected above stated reporting limit, minimum detection limit shown
Kitsap County Tax Parcel Line
Former Gas Works Property
Historical Structures
Locations and dimensions of historical features are based on historical information of varying accuracy, including maps and sketches not to scale.
PORT WASHINGTON NARROWS
Current Shoreline (OHW)
BGW-RE-HA-01
BGW-RE-GP-01
MP04
(66.3)
MW-8
(42.1)
MW-5
(61.1)
MW-7
(43.3)
MW-6
(33.3)
Sesko Property
SP03
(65.3)
SP02
(57.8)
MP03
(35)
MW-3
(36.2)
MW-4
(44.6)
MP02
(32.8)
MP01
(54)
McConkey Property
APPROX TAR PIT
MW-2
(40.6)
SP01
(58.2)
DRIP TANK
Penn Plaza Property
Thompson Ave
Pennsylvania Ave
MW-1
(32.5)
N
0
50
100
Feet
1:600
Nickel Concentrations in Subsurface Soil (Below 10 Feet)
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington
Aspect CONSULTING
ANCHOR QEA
FIRM: ASPECT
DRAWN BY: CB / HRL
FIGURE NO.
3-14
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

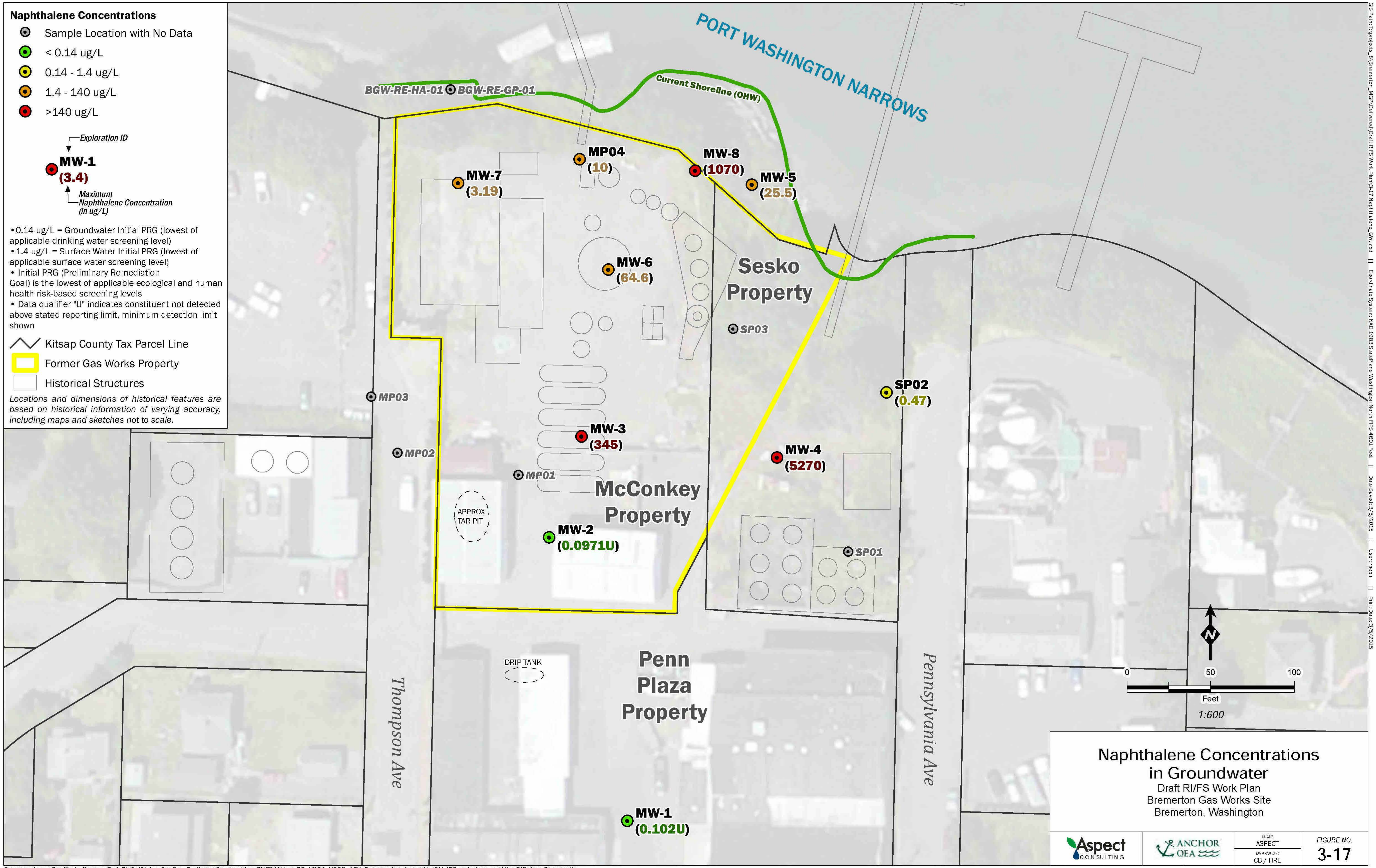


Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

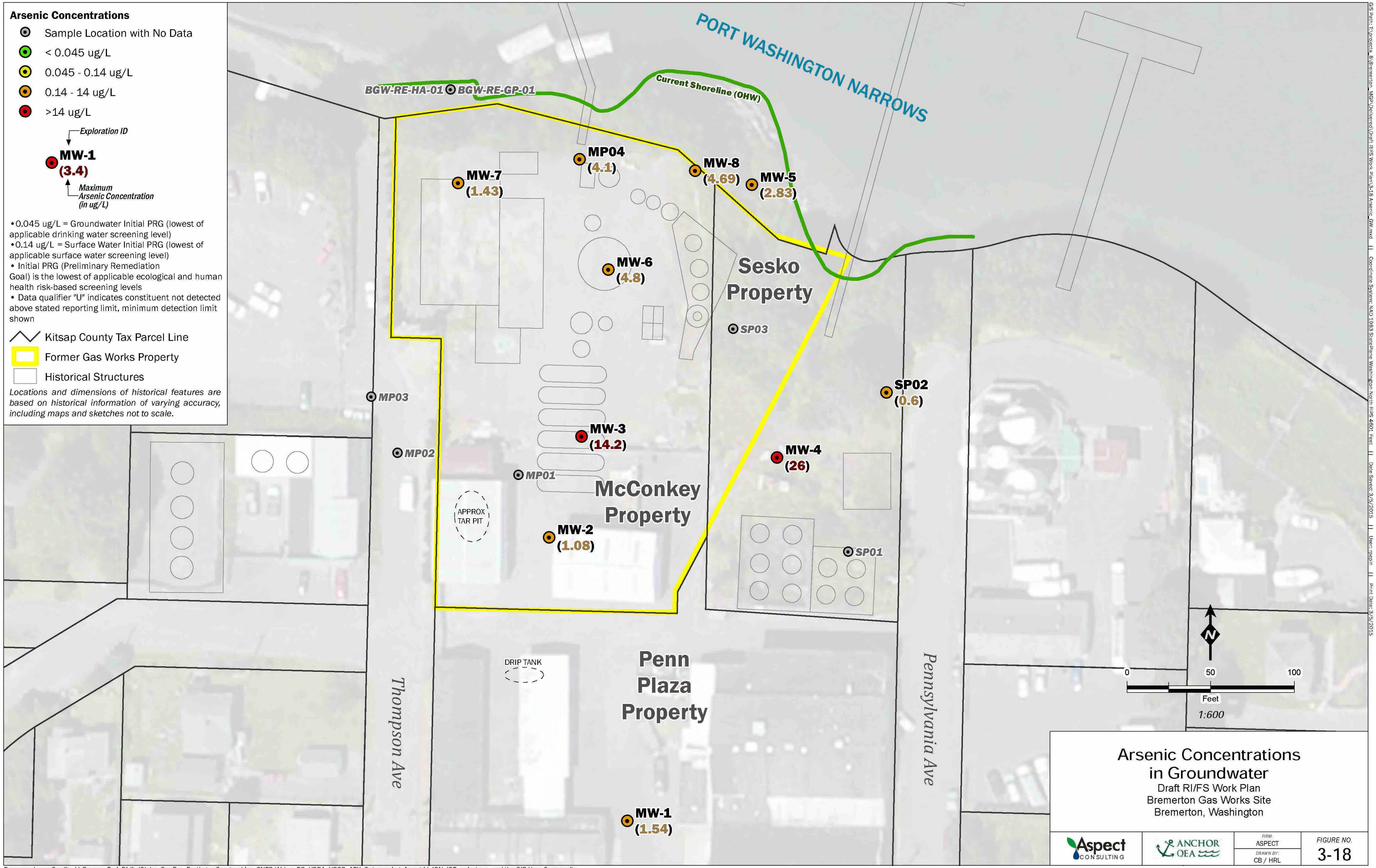


Total cPAHs Concentrations in Groundwater
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

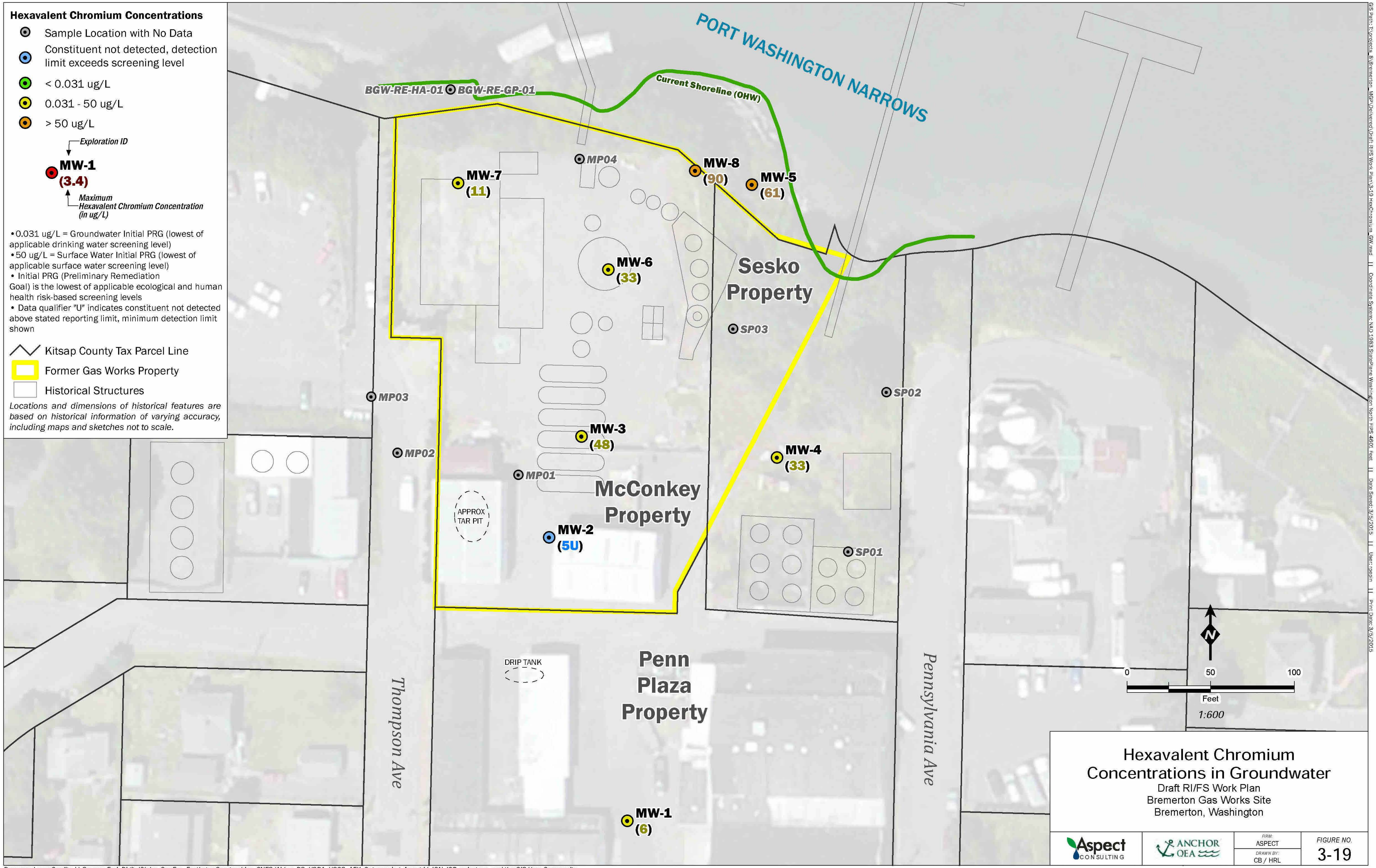
Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

DNR-00040816

NOTES:
1. Field duplicates were not included.
2. Data presented are 2013 Removal Evaluation surface samples (0-4 inches).
3. BAP – Benzo(a)pyrene

Benzo(a)pyrene µg/kg dw
- 0 - 1,600
- 1,610 - 3,000
- > 3,000

- 2010 TCRA/IA Pipe Plug Location
- Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
- Field-located Sanitary Sewer Line
- Sanitary Sewer *(Not Field Located)*
- Sewer Line Continues West from this Location
- Field Verified Pipe Location
- Remaining 12-inch Concrete Pipe
- Pipe Removed and Backfilled to Grade
- Cover of Existing Organoclay Mat (10-inch minus rock)
- Extent of Existing Organoclay Mat

N

0 25 50

Feet

1:600

Surface Sediment Benzo(a)pyrene Concentrations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING

ANCHOR QEA

FIRM: ANCHOR QEA
DRAWN BY: ckiblinger

FIGURE NO. **3-20**

NOTES:
1. Field duplicates were not included.
2. Data presented are 2013 Removal Evaluation surface samples (0-4 inches).
3. LPAH – Low molecular weight PAH.

Total LPAH (SMS) (U = 0) µg/kg dw
- 0 - 5,200
- 5,210 - 13,000
- > 13,000

- 2010 TCRA/IA Pipe Plug Location
- Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
- Field-located Sanitary Sewer Line
- Sanitary Sewer *(Not Field Located)*
- Sewer Line Continues West from this Location

- Field Verified Pipe Location
- Remaining 12-inch Concrete Pipe
- Pipe Removed and Backfilled to Grade
- Cover of Existing Organoclay Mat (10-inch minus rock)
- Extent of Existing Organoclay Mat

N

0 25 50
Feet
1:600

Surface Sediment LPAH Concentrations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR QEA DRAWN BY: ckiblinger | FIGURE NO. 3-21

NOTES:
1. Field duplicates were not included.
2. Data presented are Anchor and Aspect (2013) Removal Evaluation subsurface samples (>4 inches) and E & E (2008) Targeted Brownfields Assessment samples (0 to 1 foot).
3. HPAH – High molecular weight PAH.

Total HPAH (SMS) (U = 0) µg/kg dw
- 0 - 12,000
- 12,100 - 17,000
- > 17,000

- 2010 TCRA/IA Pipe Plug Location
- Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
- Field-located Sanitary Sewer Line
- Sanitary Sewer *(Not Field Located)*
- Sewer Line Continues West from this Location

- Field Verified Pipe Location
- Remaining 12-inch Concrete Pipe
- Pipe Removed and Backfilled to Grade
- Cover of Existing Organoclay Mat (10-inch minus rock)
- Extent of Existing Organoclay Mat

0 25 50
Feet
1:600

Surface Sediment HPAH Concentrations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR QEA | DRAWN BY: ckiblinger | FIGURE NO. 3-22

NOTES:
1. Field duplicates were not included.
2. Data presented are Anchor and Aspect (2013) Removal Evaluation subsurface samples (>4 inches) and E & E (2008) Targeted Brownfields Assessment samples (0 to 1 foot).
3. cPAH – Carcinogenic Polycyclic Aromatic Hydrocarbon (EPA 1993).
4. Sum of cPAHs (without applying any toxicity factors) including: Benzo(a)pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, Chrysene.

Total cPAH Sum (U = 1/2) µg/kg dw
- 0 - 10,000
- 10,001 - 25,000
- 25,001 - 100,000
- 100,001 - 250,000
- > 250,000

- 2010 TCRA/IA Pipe Plug Location
- Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
- Field-located Sanitary Sewer Line
- Sanitary Sewer *(Not Field Located)*
- Sewer Line Continues West from this Location

- Field Verified Pipe Location
- Remaining 12-inch Concrete Pipe
- Pipe Removed and Backfilled to Grade
- Cover of Existing Organoclay Mat (10-inch minus rock)
- Extent of Existing Organoclay Mat

N

0 25 50
Feet
1:600

Surface Sediment Sum of cPAH Concentrations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING
ANCHOR QEA
FIRM: ANCHOR QEA
DRAWN BY: ckiblinger
FIGURE NO. **3-23**

NOTES:
1. Field duplicates were not included.
2. Data presented are Anchor and Aspect (2013) Removal Evaluation subsurface samples (>4 inches) and E & E (2008) Targeted Brownfields Assessment samples (0 to 1 foot).
3. cPAH – Carcinogenic Polycyclic Aromatic Hydrocarbon (EPA 1993).
4. cPAH Parameters: Benzo(a)pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, Chrysene.

Total cPAH TEQ (U = 1/2) µg/kg dw
- 0 - 80
- 81 - 800
- 801 - 8,000
- 8,001 - 80,000
- > 80,000

- 2010 TCRA/IA Pipe Plug Location
- Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
- Field-located Sanitary Sewer Line
- Sanitary Sewer *(Not Field Located)*
- Sewer Line Continues West from this Location

- Field Verified Pipe Location
- Remaining 12-inch Concrete Pipe
- Pipe Removed and Backfilled to Grade
- Cover of Existing Organoclay Mat (10-inch minus rock)
- Extent of Existing Organoclay Mat

N

0 25 50

Feet

1:600

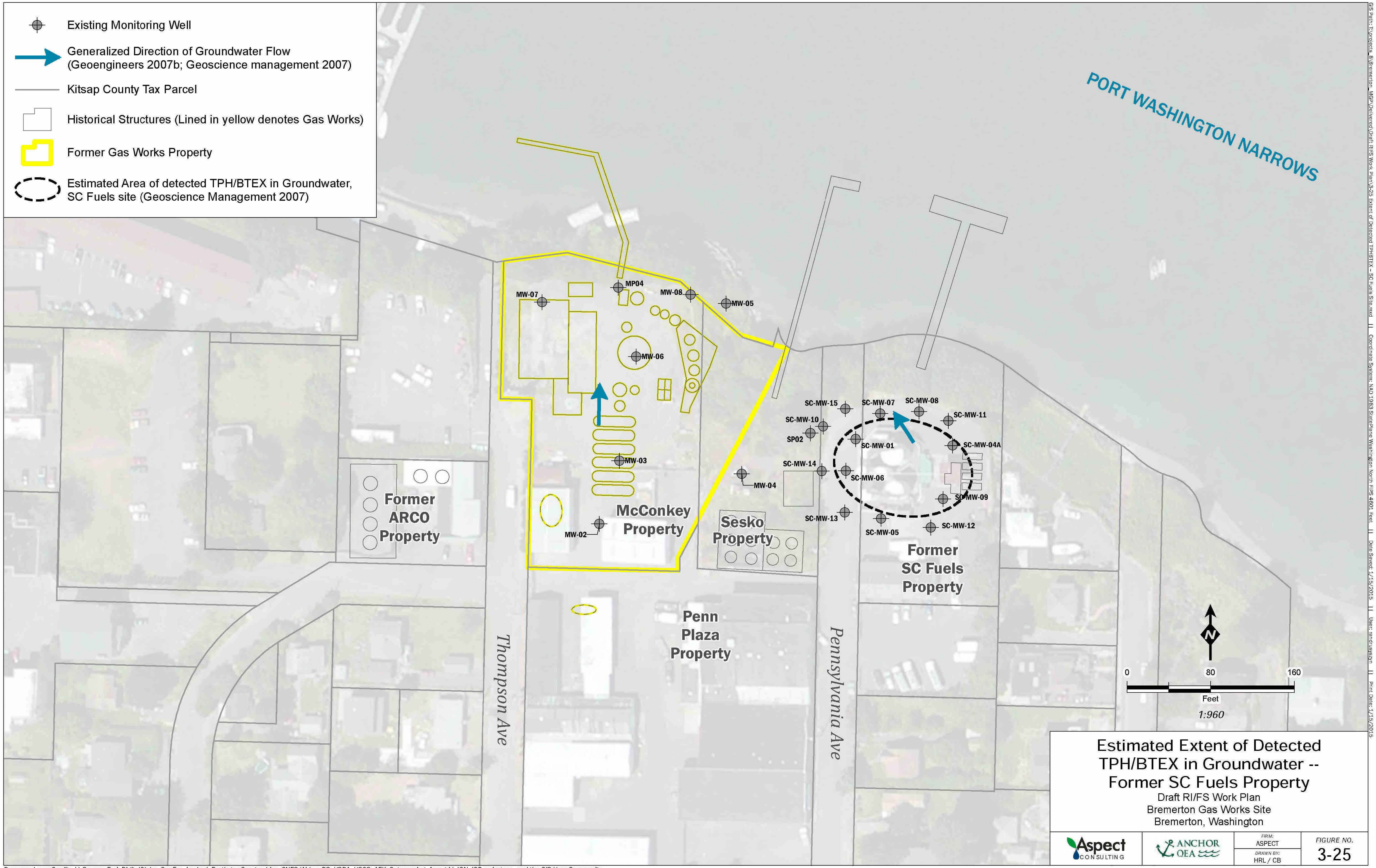
Surface Sediment cPAH TEQ Concentrations
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING

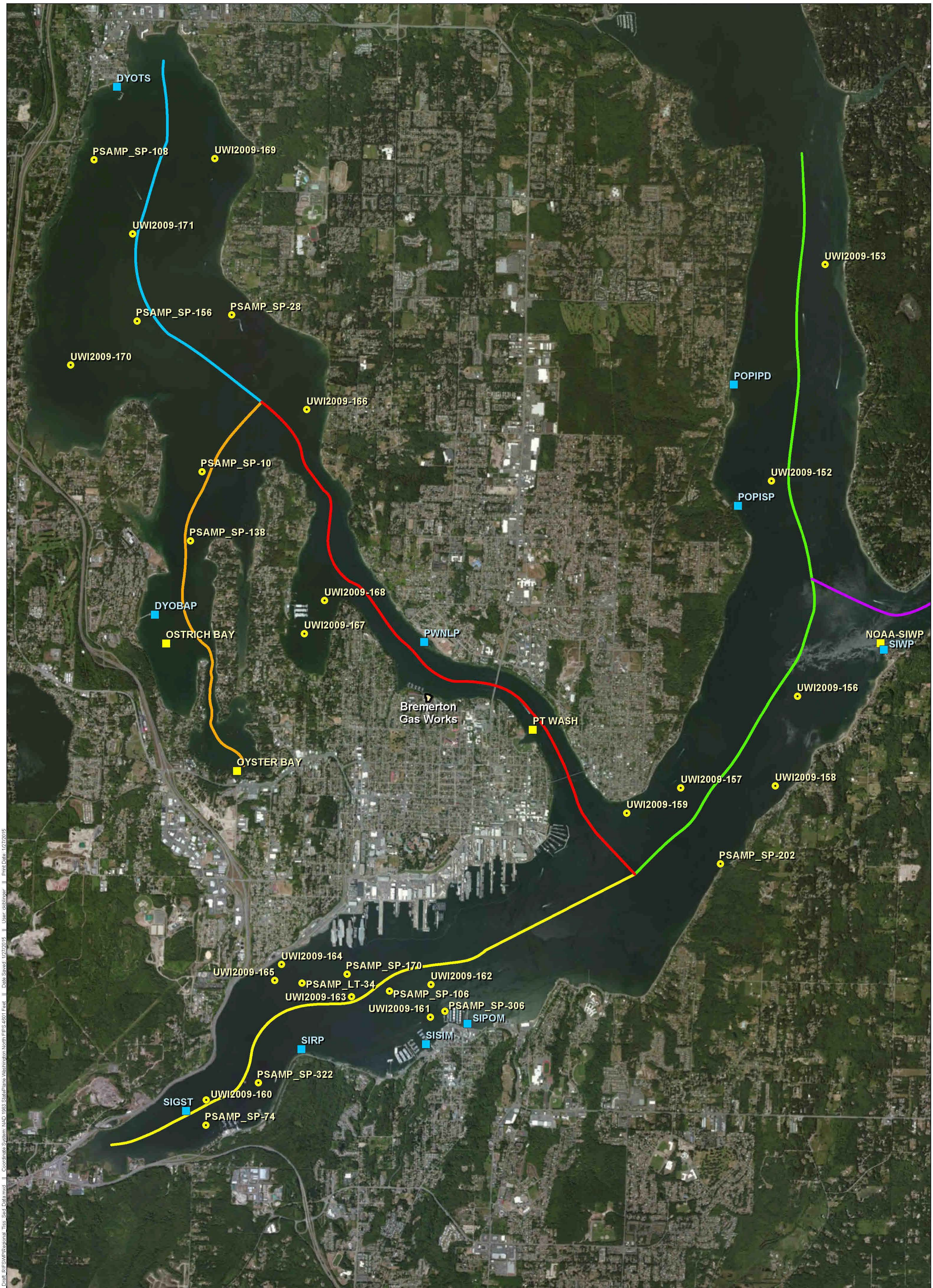
ANCHOR QEA

FIRM: ANCHOR QEA
DRAWN BY: ckiblinger

FIGURE NO.
3-24



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



ENVVEST Stations

Tissue

EIM Stations

Sediment

Tissue

Dyes Inlet

Ostrich Bay

Port Orchard

Port Washington Narrows

Rich Passage

Sinclair Inlet

N

0 1,750 3,500

Feet

1:42,000

Locations of Regional Tissue and Sediment Data

Draft RI/FS Work Plan

Bremerton Gas Works Site

Bremerton, Washington

Aspect CONSULTING

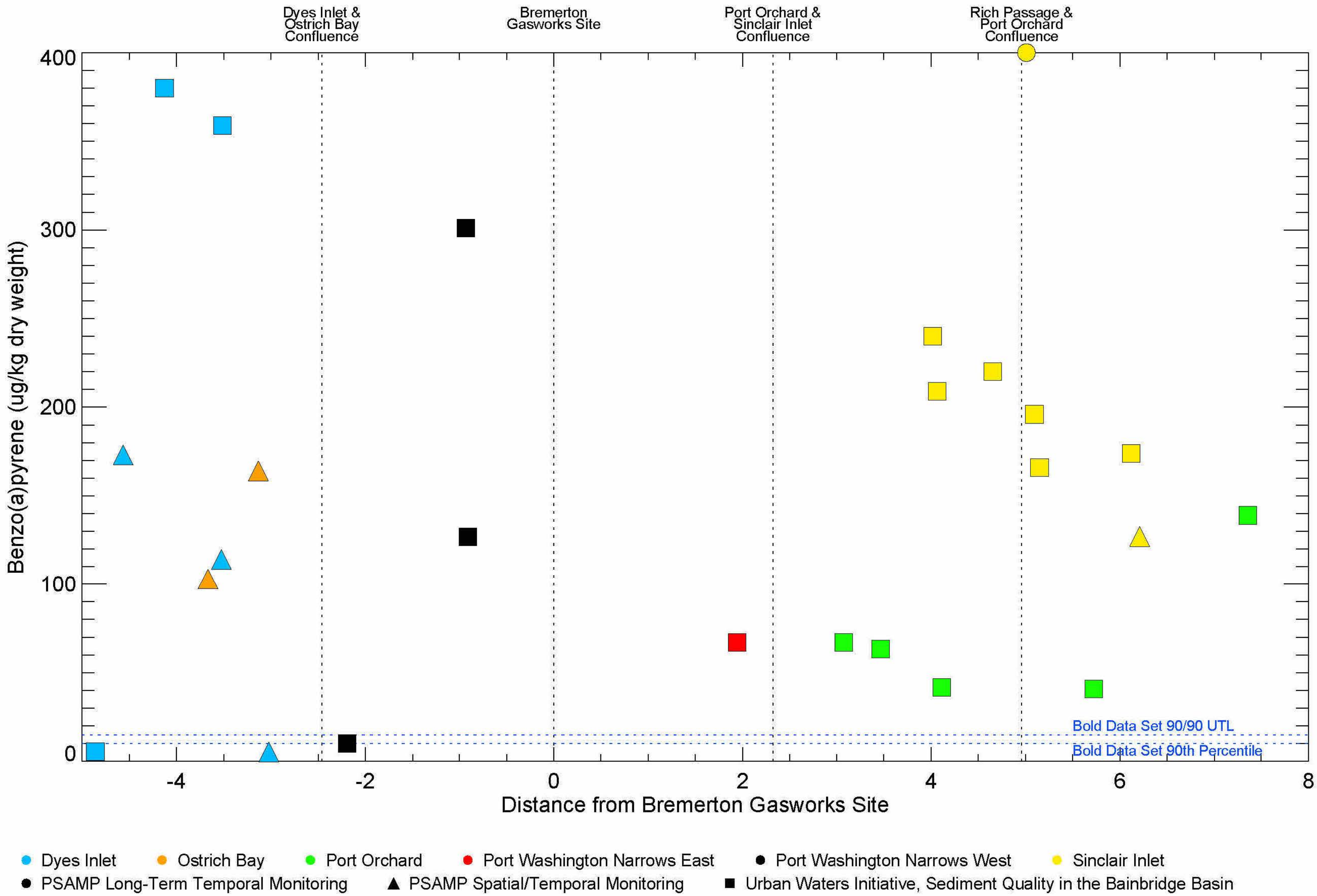
ANCHOR QEA

FIRM: ANCHOR QEA

DRAWN BY: ckiblinger

FIGURE NO. 3-26

DNR-00040823

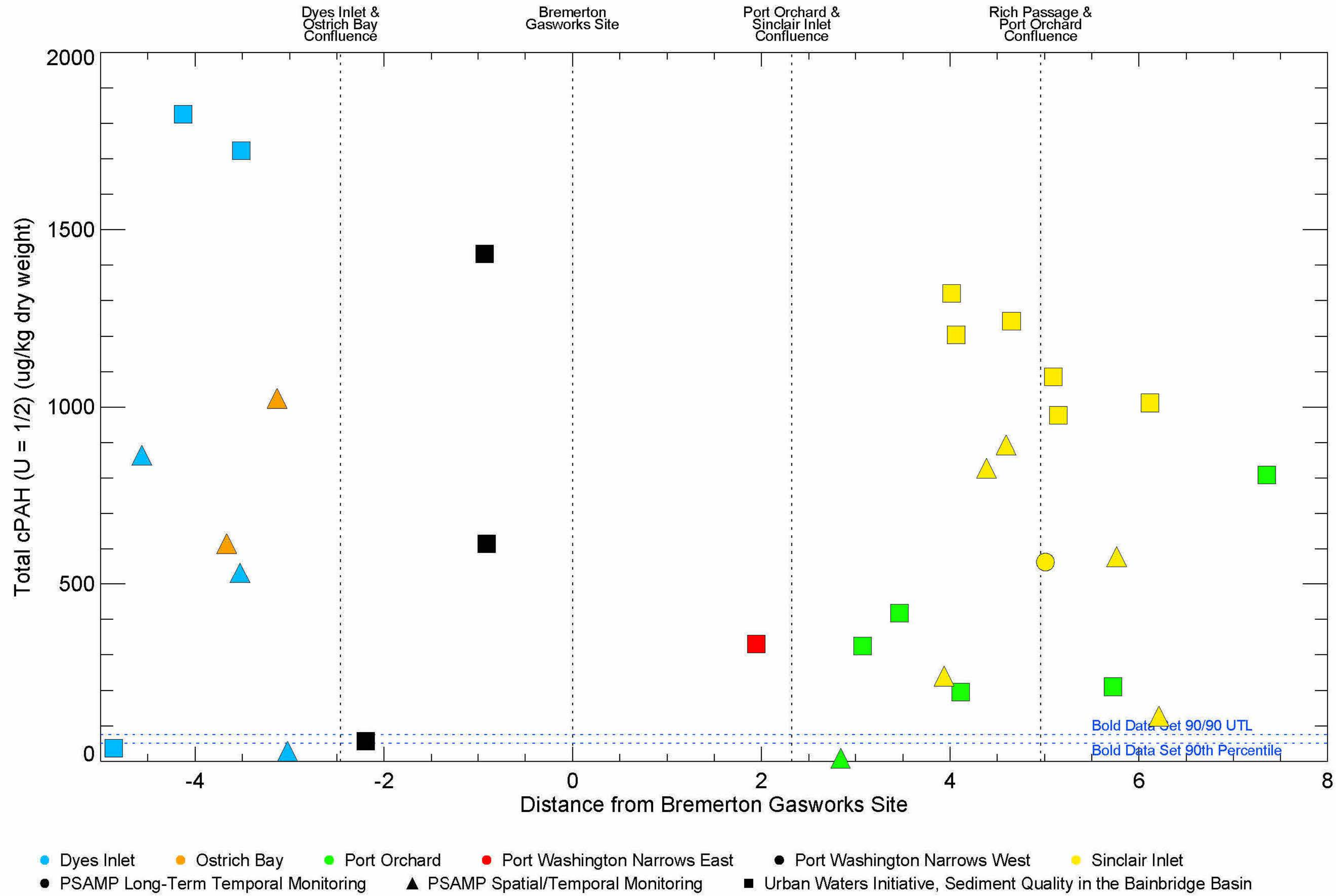


Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
PSAMP = Puget Sound Assessment and Monitoring Program.

Total Benzo(a)pyrene Concentrations in Existing Sediment Data

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 3-27

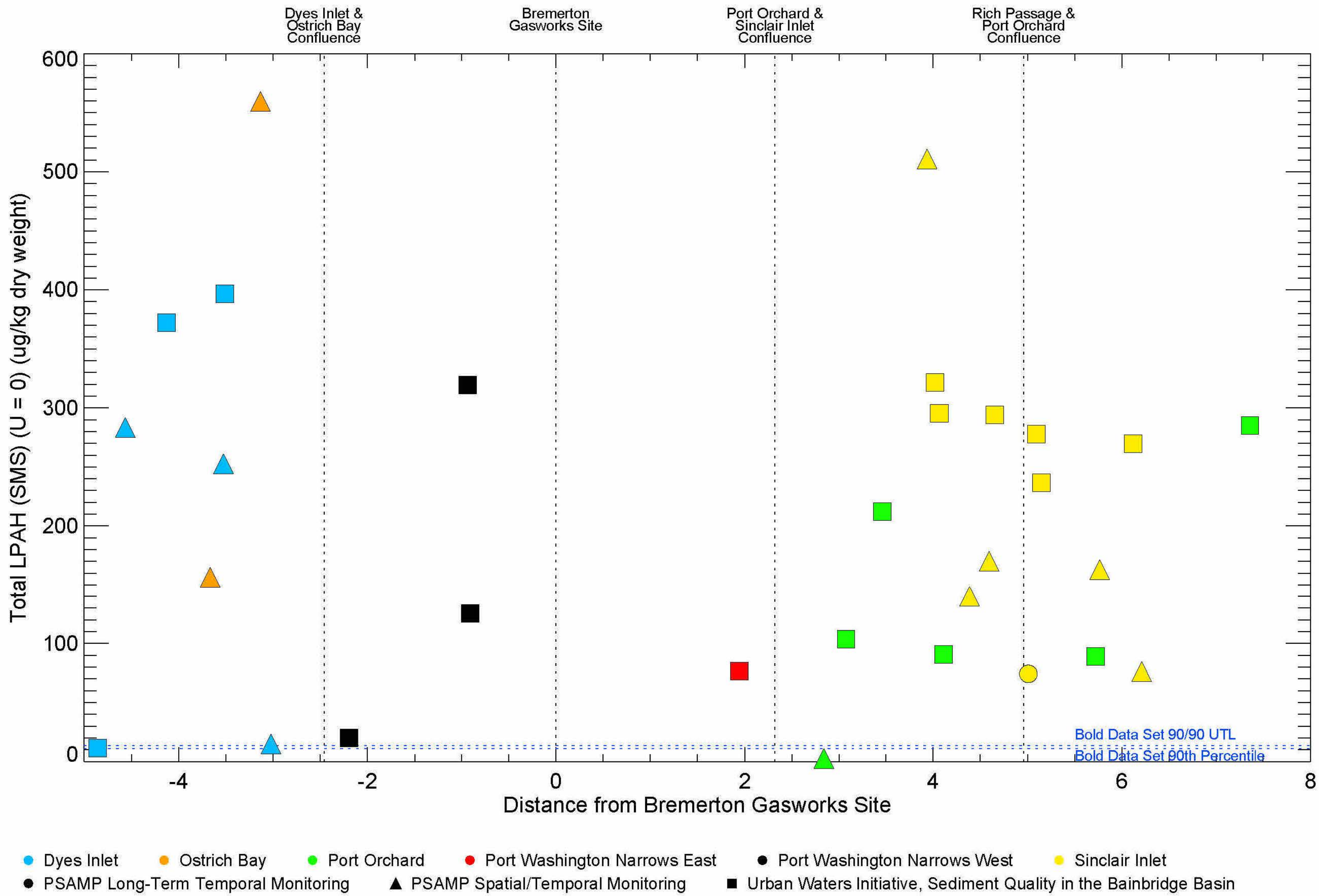


Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
PSAMP = Puget Sound Assessment and Monitoring Program.

Total cPAH Concentrations in Existing Sediment Data

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 3-28

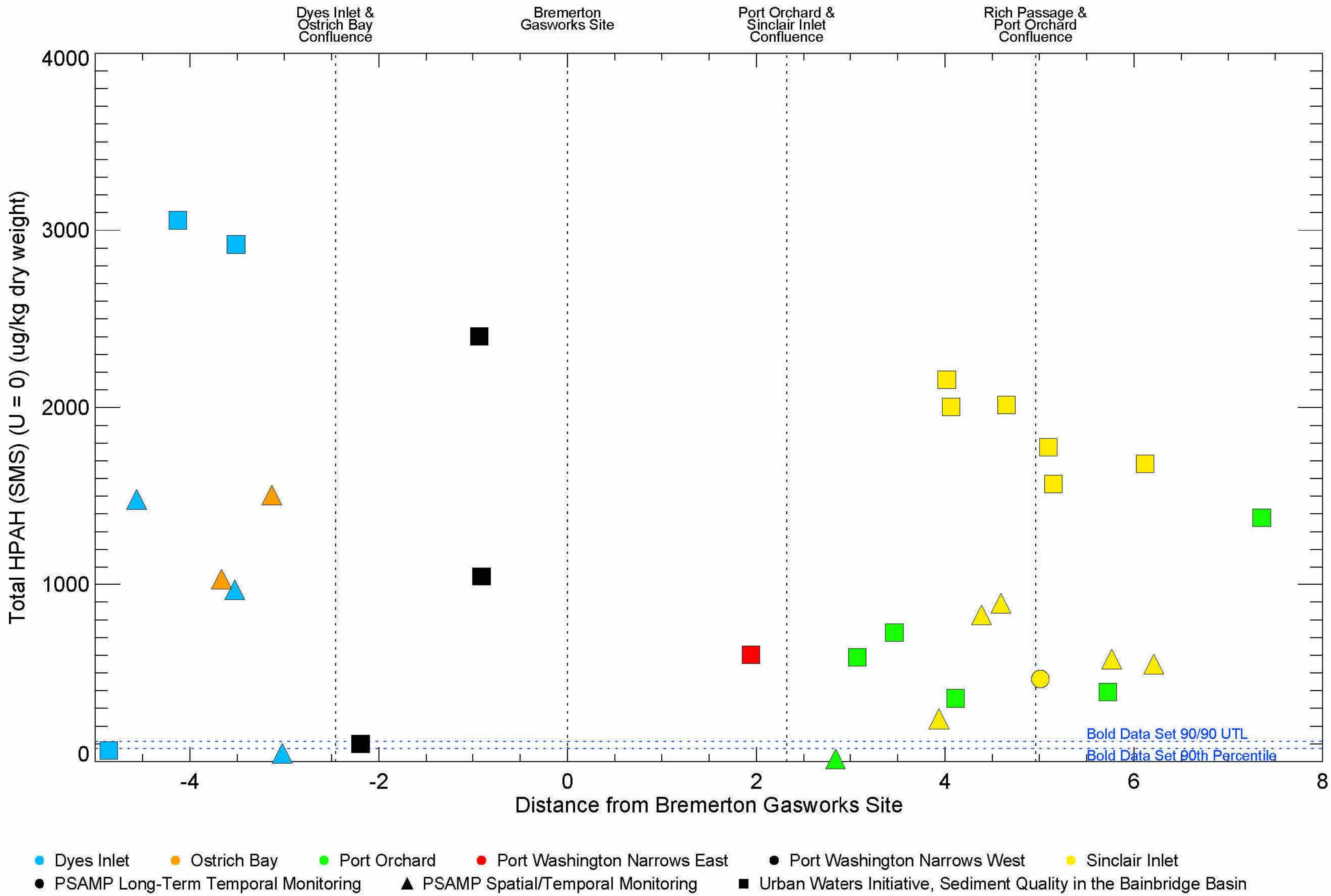


Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
PSAMP = Puget Sound Assessment and Monitoring Program.

Total LPAH Concentrations in Existing Sediment Data

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 3-29

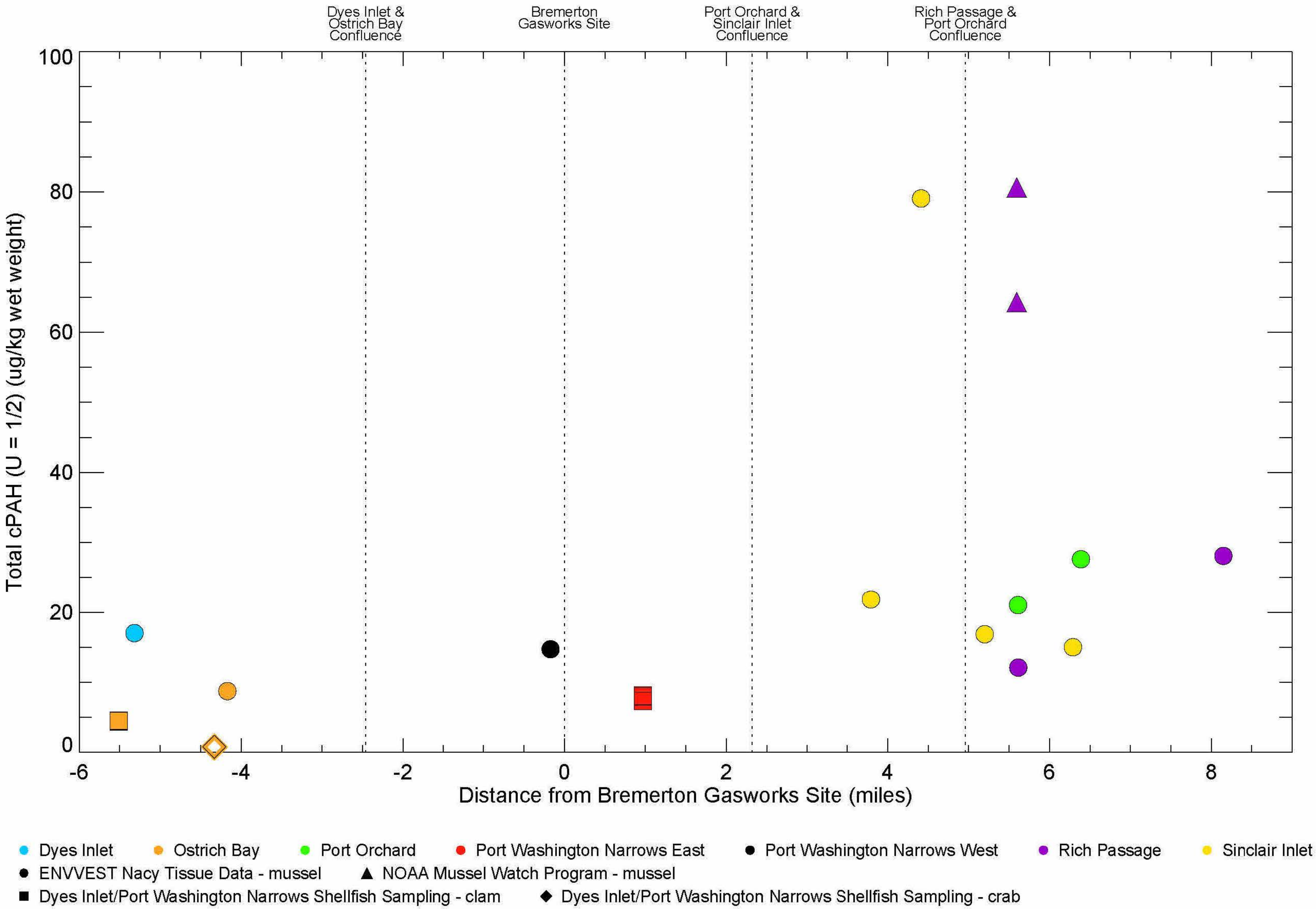


Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
PSAMP = Puget Sound Assessment and Monitoring Program.

Total HPAH Concentrations in Existing Sediment Data

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR | DRAWN BY: --- | FIGURE NO. 3-30

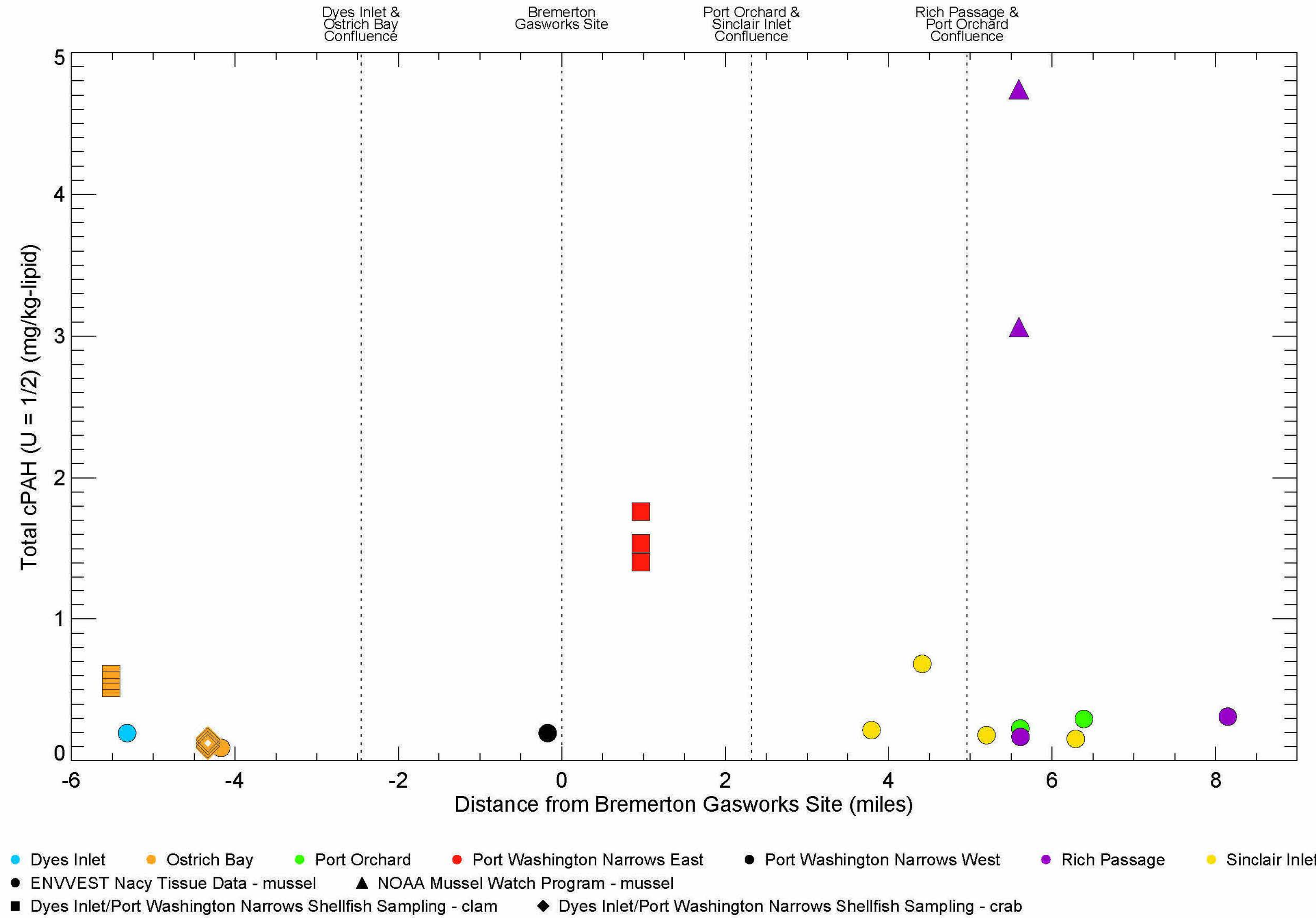


Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
Detected values plotted with filled symbols. Non-detects plotted with open symbols.

Total cPAH Concentrations in Existing Tissue Data (Wet Weight Basis)

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR
DRAWN BY: --- | FIGURE NO. 3-31



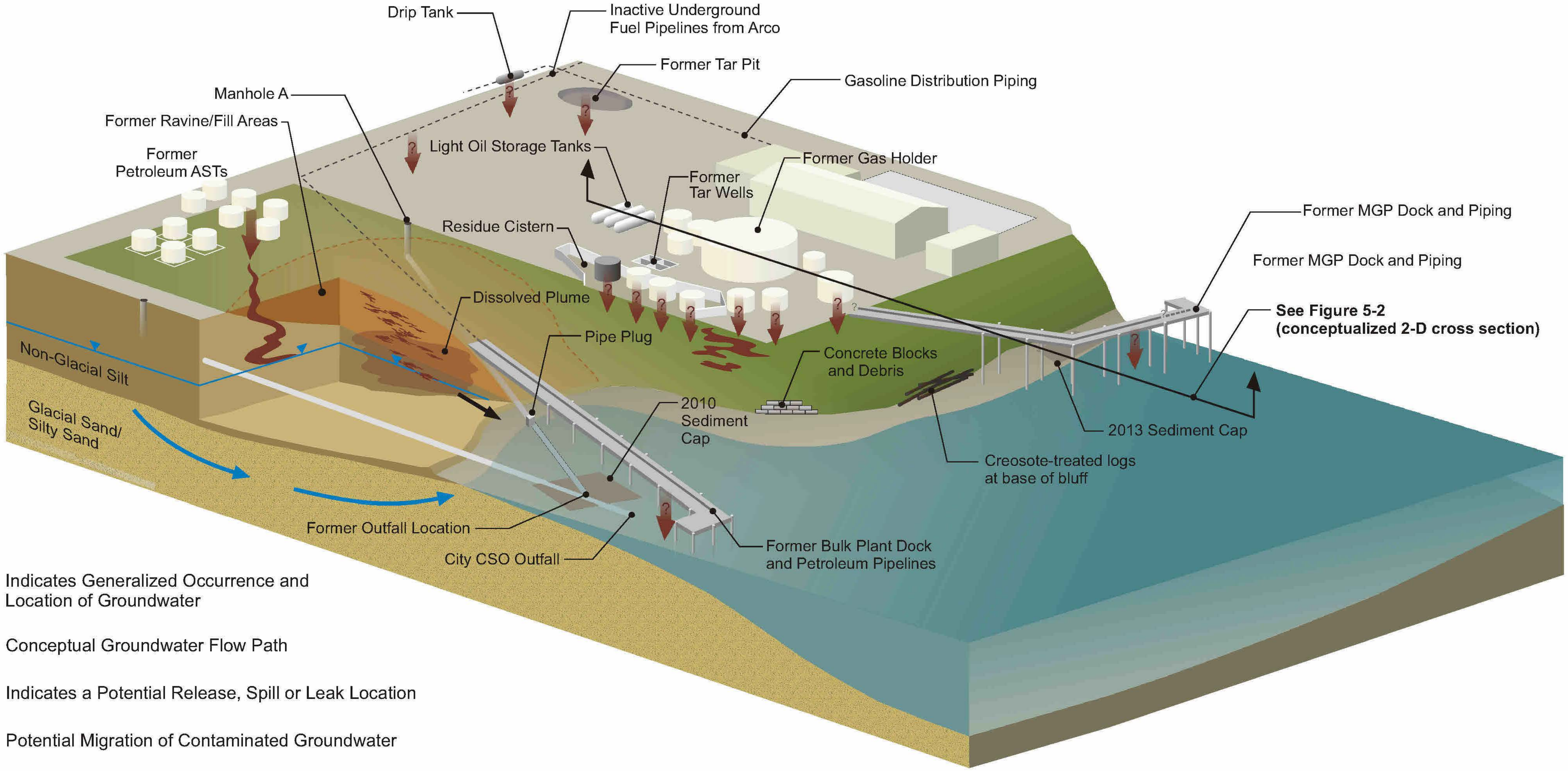
Notes: Negative distances represent waterways west of Bremerton Gasworks site.
Positive distances represent waterways east of the site.
Detected values plotted with filled symbols. Non-detects plotted with open symbols.

Total cPAH Concentrations in Existing Tissue Data (Lipid-Normalized Basis)

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 3-32

GIS Path: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\3-32 Total cPAH Conc Lipid.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 2/19/2015 || User: rpepin || Print Date: 2/19/2015



Indicates Generalized Occurrence and Location of Groundwater

Conceptual Groundwater Flow Path

Indicates a Potential Release, Spill or Leak Location

Potential Migration of Contaminated Groundwater

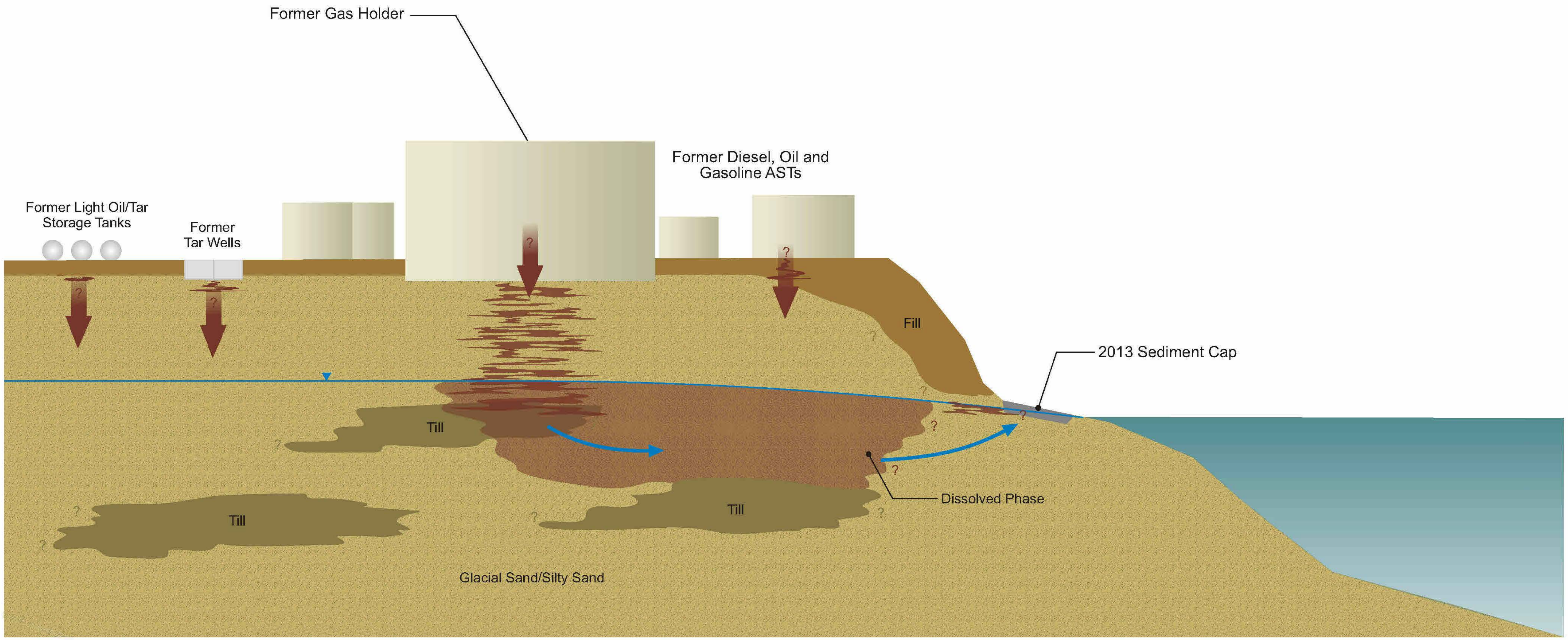
Conceptual Representation of Subsurface Non-aqueous Phase Liquid (NAPL) Occurrence and Migration

Note: Not to Scale

Preliminary Conceptual Site Model

Draft RI/FS Work Plan
Former Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT / DRAWN BY: CB / RAA | FIGURE NO. 4-1



Indicates Generalized Occurrence and Location of Groundwater

Conceptual Groundwater Flow Path

Indicates a Potential Release, Spill or Leak Location

Conceptual Representation of Subsurface Non-aqueous Phase Liquid (NAPL) Occurrence and Migration

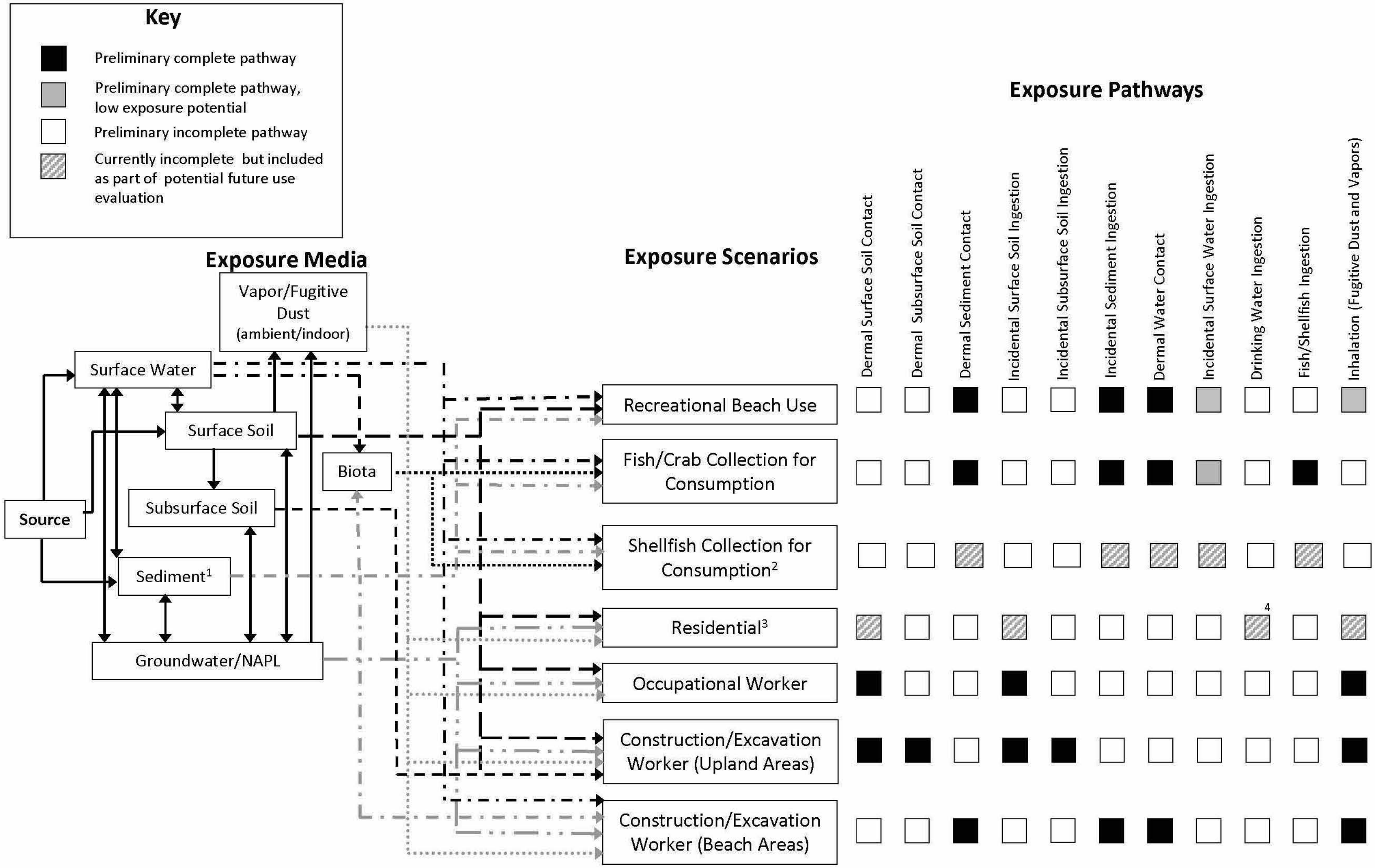
Note: Not to Scale

Conceptualized CSM Cross Section

Draft RI/FS Work Plan
Former Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ASPECT | DRAWN BY: CB / RAA | FIGURE NO. 4-2

GIS Path: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\4-2 Conceptualized CSM Cross Section.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/15/2015 || User: randrusyszyn || Print Date: 1/15/2015

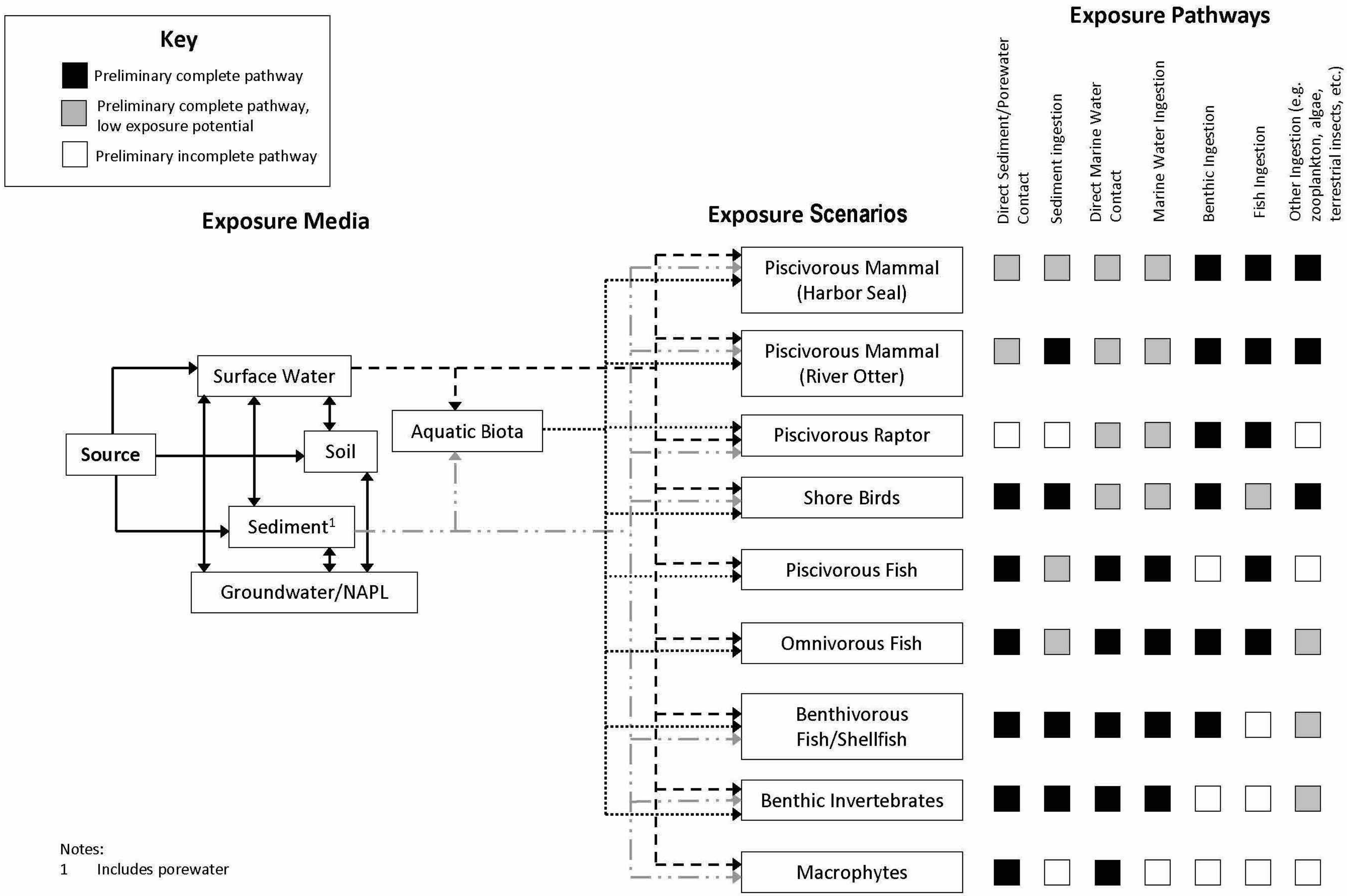


Notes:
1 Includes sediment porewater
2 The portions of Port Washington Narrows adjacent to the Gas Works are currently listed as closed to shellfish harvesting (due to water quality concerns associated with combined sewer overflows and issues not related to the site) by the Washington Department of Health; however, exposures associated with shellfish harvesting will be evaluated to understand potential risks should shellfish harvest restrictions be lifted in the future.
3 The Gas Works property and the adjacent properties are zoned and used for industrial uses; however, residential property exposures will be evaluated to understand potential implications should property uses be converted to residential at some point in the future.
4 No water supply wells are located on or near the former Gas Works; however, groundwater ingestion is retained for screening pending further evaluation of groundwater beneficial uses.

Human Health Conceptual Site Model

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR; DRAWN BY: --- | FIGURE NO. 4-3

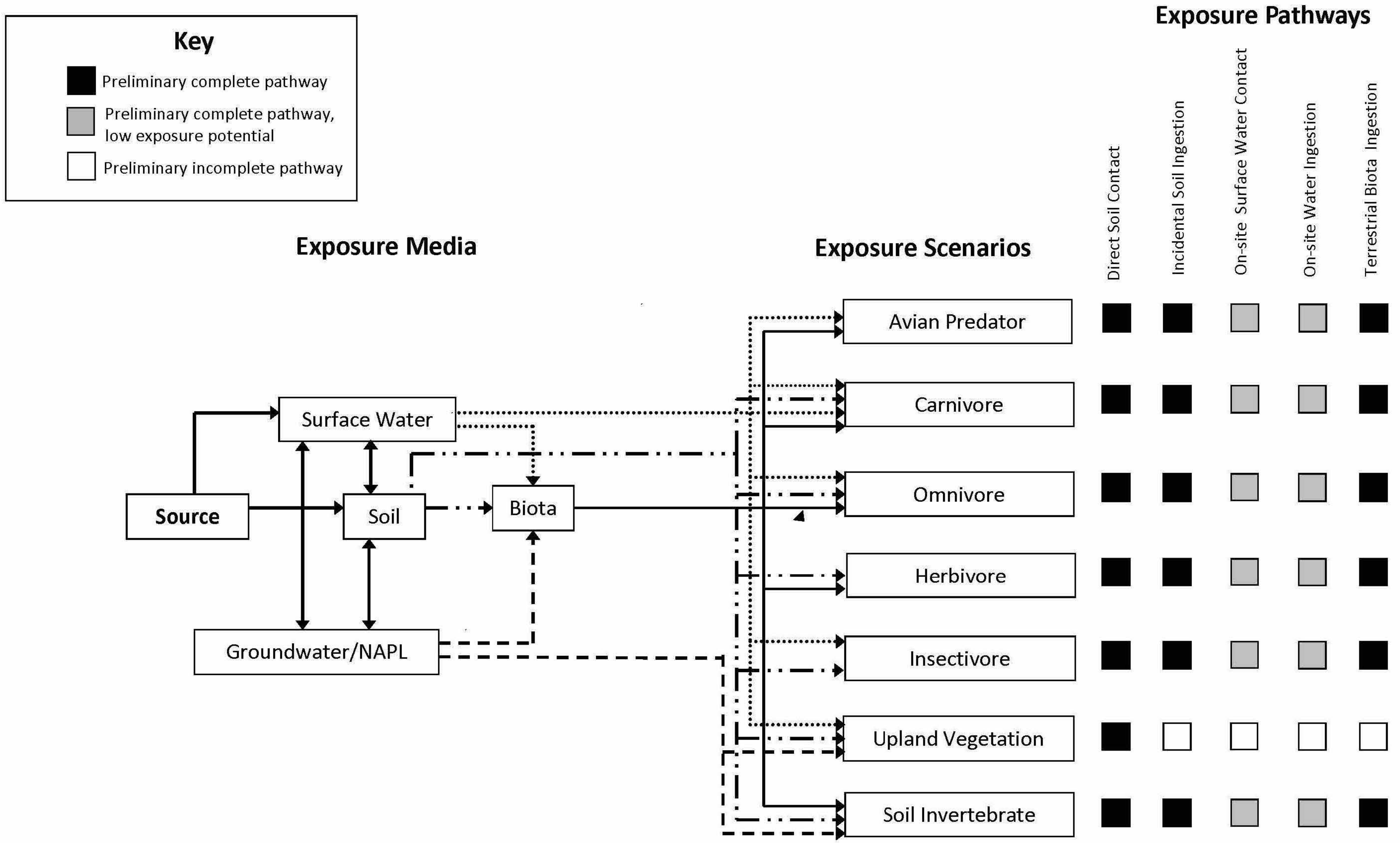


Notes:
1 Includes porewater

Aquatic Dependent Wildlife Conceptual Site Model

Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 4-4

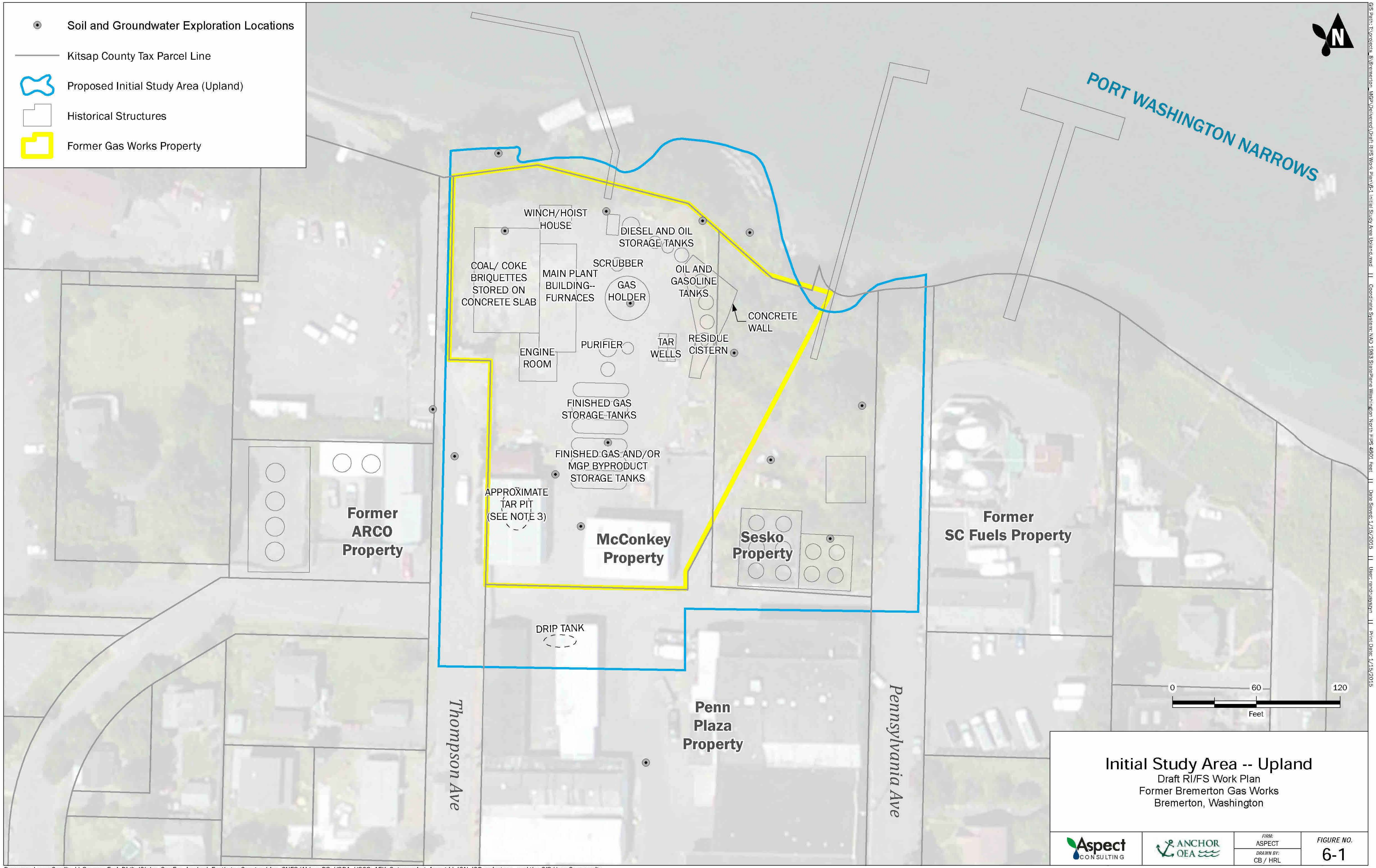


Notes:
The majority of the upland portion of the Gas Works site is paved. Unpaved areas include the adjacent bluff and former ravine.
On-site freshwater is ephemeral and consists of ponding after rain events.

Terrestrial Wildlife Conceptual Site Model

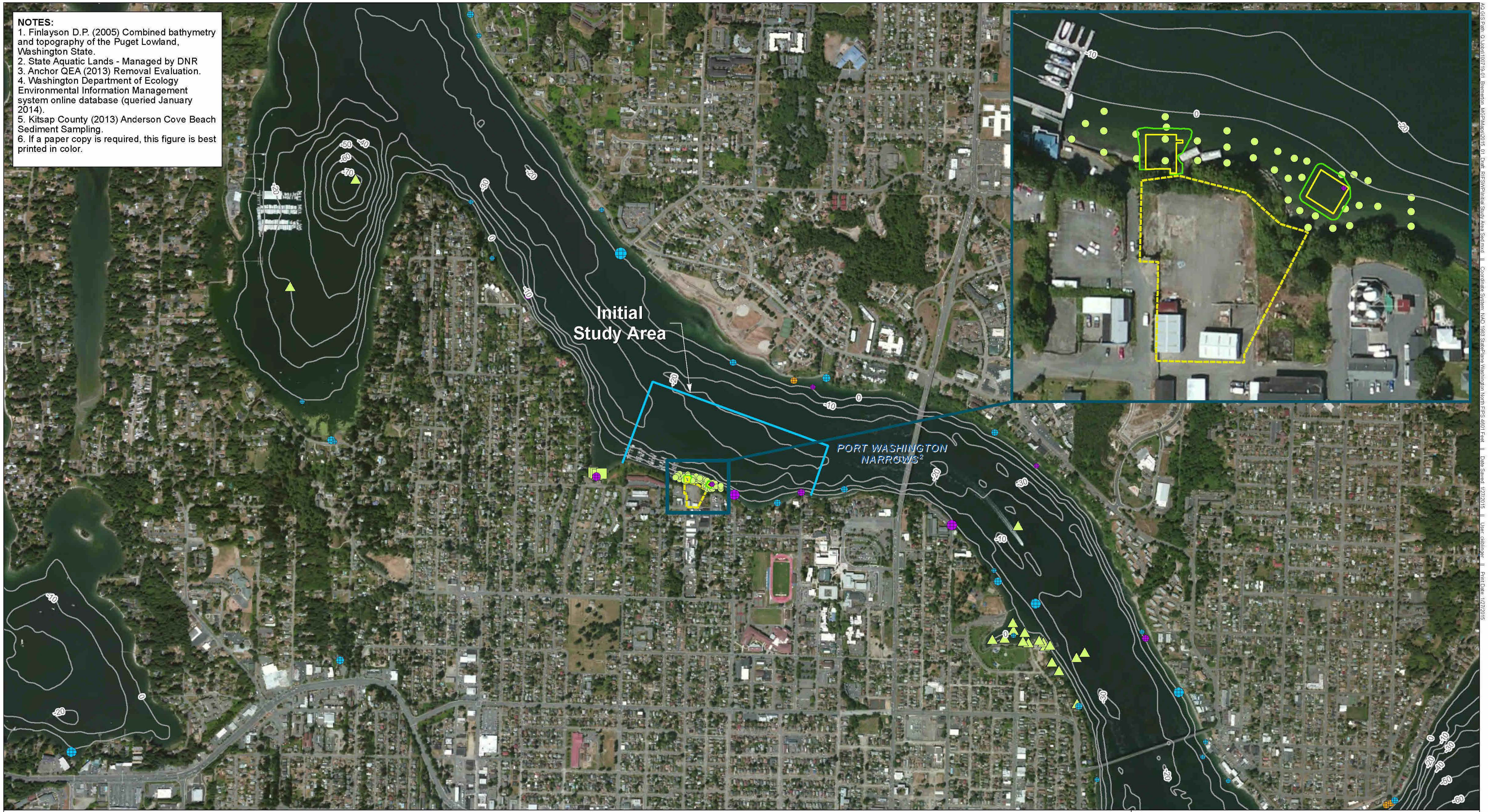
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

Aspect CONSULTING | ANCHOR QEA | FIRM: ANCHOR DRAWN BY: --- | FIGURE NO. 4-5



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

DNR-00040835



Initial Study Area[3]
Former Gas Works Location
Cover of Existing Organoclay Mat (10-inch minus rock)[2]
Extent of Existing Organoclay Mat[2]

Surface Sediment Data Source
- Anchor QEA[3]
- EIM[4]
- Kitsap County[5]

Outfall Size (inches)
- 8 - 12
- 13 - 24
- 25 - 36
- 37 - 48
- 49 - 60
- 61 - 72
- 73 - 84

Outfall Type
- Combined Storm Drain/CSO Outfall
- CSO Outfall
- Storm Drain

PSDEM 2005 10-foot Contours[1]

N

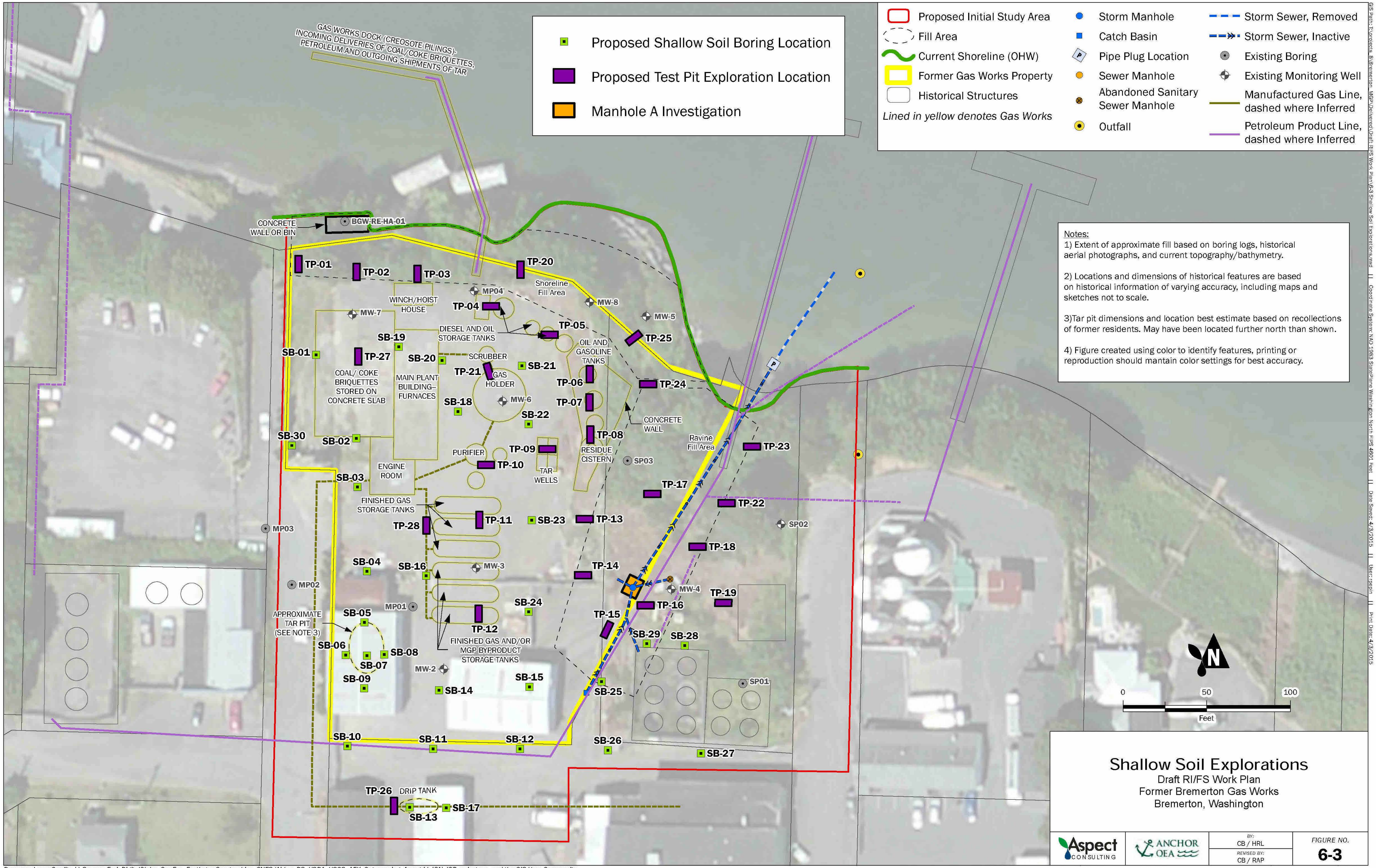
0 500 1,000
Feet
1:13,327

Initial Study Area – Sediments
Draft RI/FS Work Plan
Bremerton Gas Works Site
Bremerton, Washington

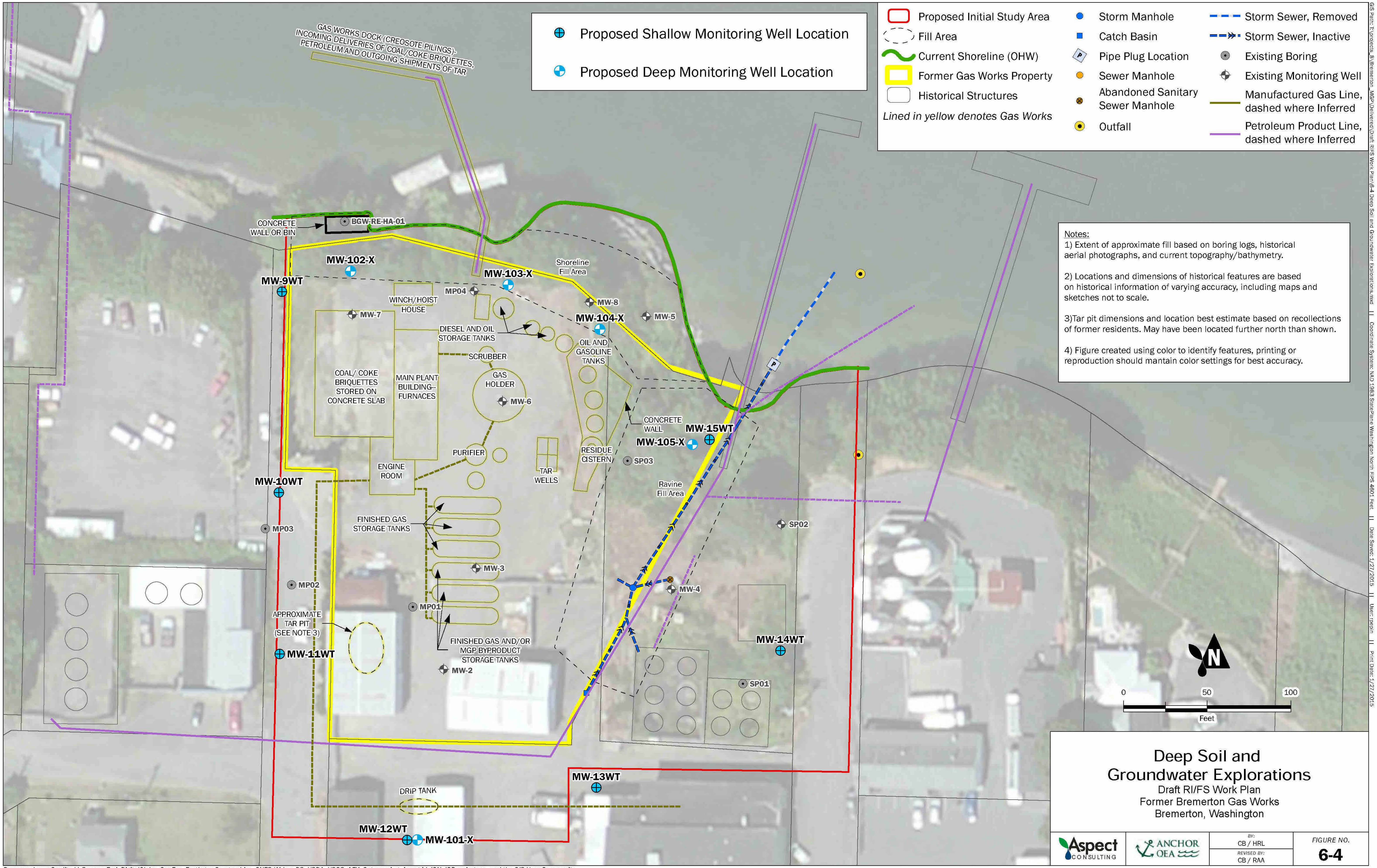
Aspect CONSULTING
ANCHOR QEA

FIRM: ANCHOR QEA
DRAWN BY: ckiblinger

FIGURE NO.
6-2



Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Notes:
1) Extent of approximate fill based on boring logs, historical aerial photographs, and current topography/bathymetry.

2) Locations and dimensions of historical features are based on historical information of varying accuracy, including maps and sketches not to scale.

3)Tar pit dimensions and location best estimate based on recollections of former residents. May have been located further north than shown.

4) Figure created using color to identify features, printing or reproduction should mantain color settings for best accuracy.

Deep Soil and Groundwater Explorations

Draft RI/FS Work Plan
Former Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING | ANCHOR OEA

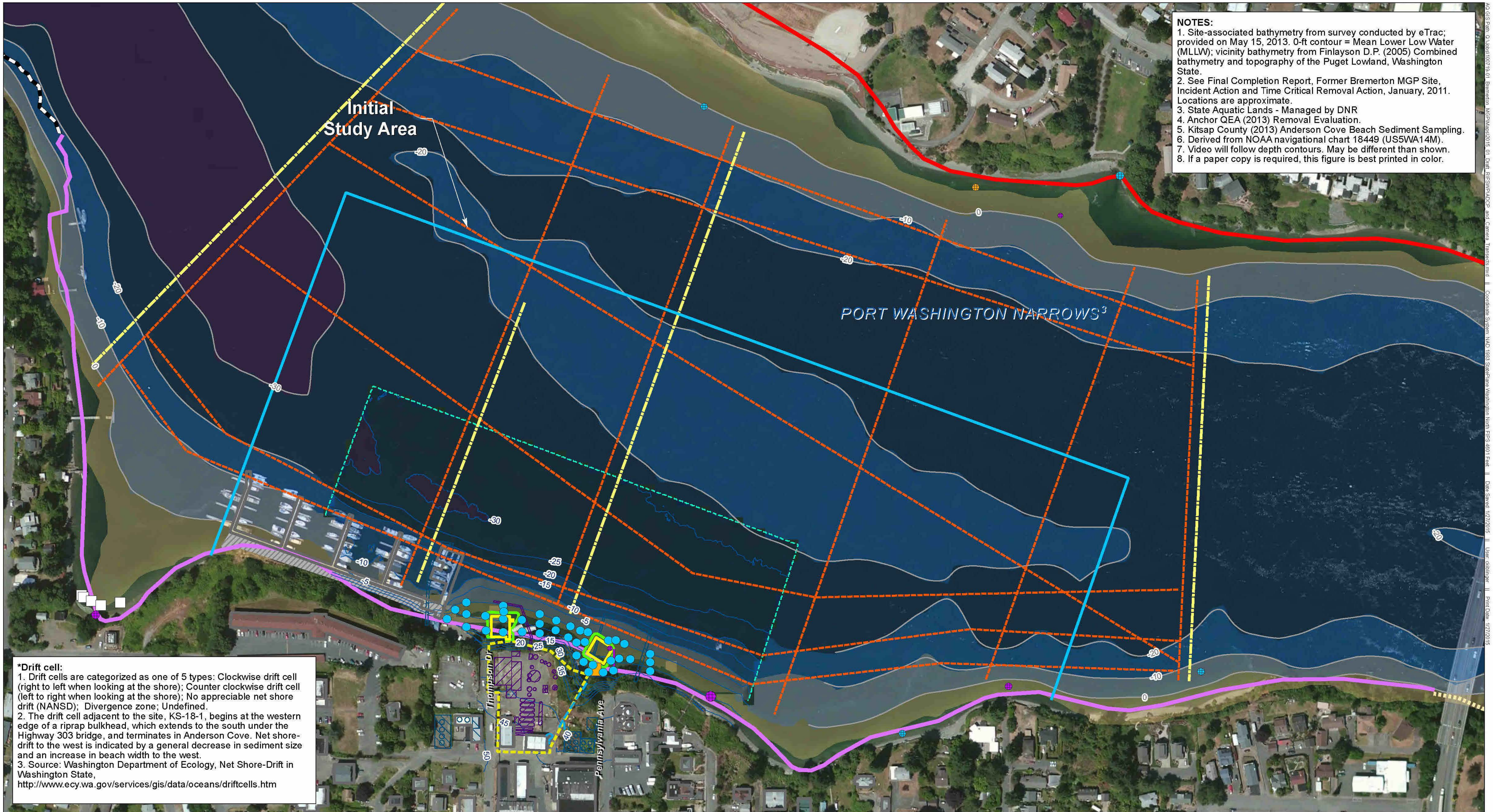
BY: CB / HRL
REVISED BY: CB / RAA

FIGURE NO. 6-4

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

GIS Path: T:\projects_8\Bremerton_MGP\Delivered\Draft RIFS Work Plan\6-4 Deep Soil and Groundwater Explorations.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/27/2015 || User: rpepin || Print Date: 1/27/2015

DNR-00040838



NOTES:
1. Site-associated bathymetry from survey conducted by eTrac; provided on May 15, 2013. 0-ft contour = Mean Lower Low Water (MLLW); vicinity bathymetry from Finlayson D.P. (2005) Combined bathymetry and topography of the Puget Lowland, Washington State.
2. See Final Completion Report, Former Bremerton MGP Site, Incident Action and Time Critical Removal Action, January, 2011. Locations are approximate.
3. State Aquatic Lands - Managed by DNR
4. Anchor QEA (2013) Removal Evaluation.
5. Kitsap County (2013) Anderson Cove Beach Sediment Sampling.
6. Derived from NOAA navigational chart 18449 (US5WA14M).
7. Video will follow depth contours. May be different than shown.
8. If a paper copy is required, this figure is best printed in color.

***Drift cell:**
1. Drift cells are categorized as one of 5 types: Clockwise drift cell (right to left when looking at the shore); Counter clockwise drift cell (left to right when looking at the shore); No appreciable net shore drift (NANSD); Divergence zone; Undefined.
2. The drift cell adjacent to the site, KS-18-1, begins at the western edge of a riprap bulkhead, which extends to the south under the Highway 303 bridge, and terminates in Anderson Cove. Net shore-drift to the west is indicated by a general decrease in sediment size and an increase in beach width to the west.
3. Source: Washington Department of Ecology, Net Shore-Drift in Washington State, http://www.ecy.wa.gov/services/gis/data/oceans/driftcells.htm

Removal Evaluation Sample Locations[4]
Initial Study Area
Approximate Riprap Area
ADCP
Towed Camera[7]

Surface Sediment Data Source
Anchor QEA[4]
Kitsap County[5]
Historical Structures Associated with the Gas Works
Historical Structures Not Associated with the Gas Works
Existing Buildings
Former Gas Works Location

Drift Cells*
Undefined
Divergent zone
Transport zone (left to right)
Transport zone (right to left)
No appreciable drift

2010 TCRA/IA Pipe Plug Location[2]
Cover of Existing Organoclay Mat (10-inch minus rock)[2]
Extent of Existing Organoclay Mat[2]
Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
Bathymetry/Topography Contours (MLLW ft)[1]
Site-associated Bathymetry Extent

Outfall Size (inches)
8 - 12
13 - 24
25 - 36
37 - 48
Outfall Type
Combined Storm Drain/CSO
CSO Outfall
Storm Drain

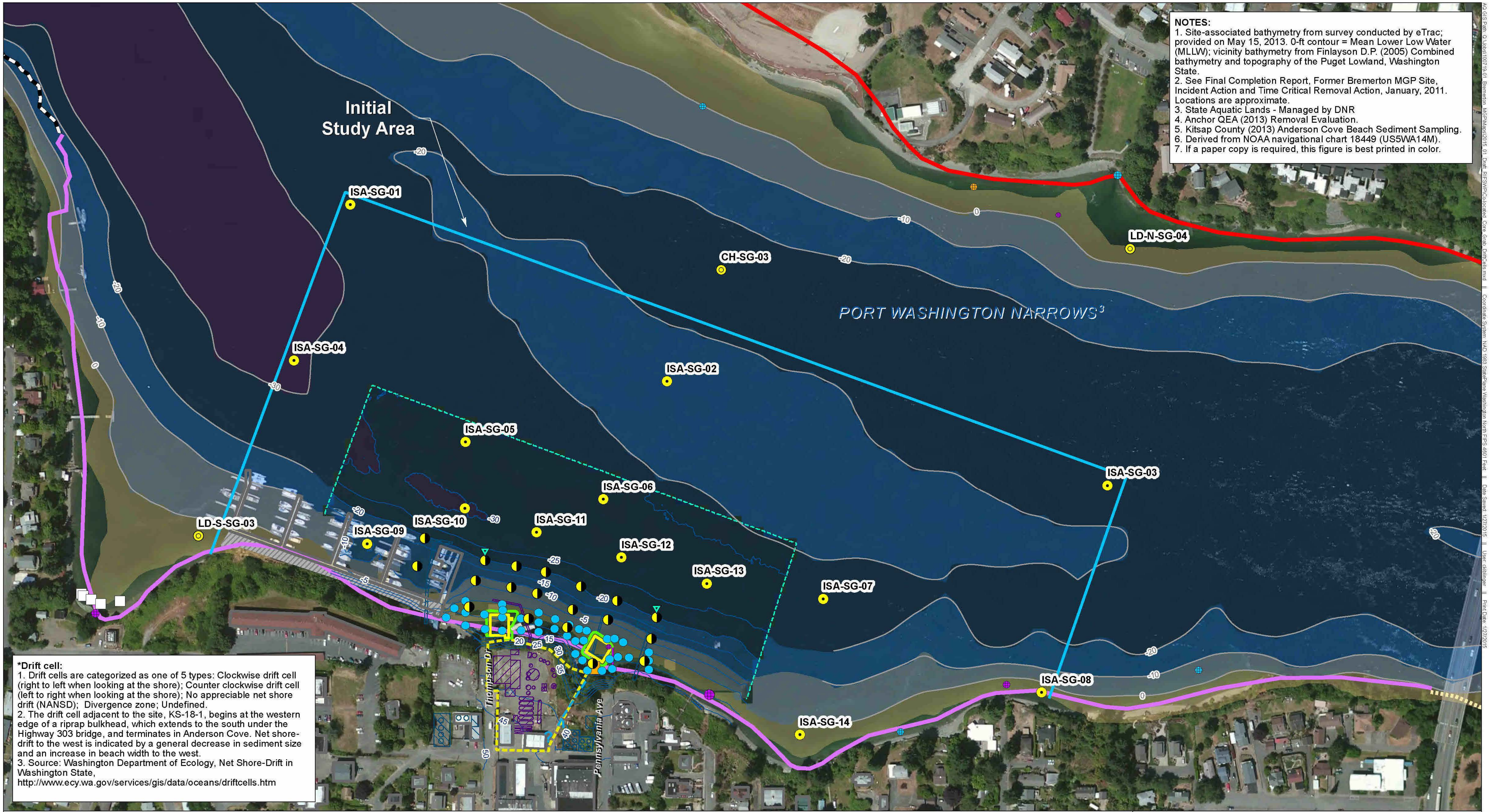
Reported Bathymetry (MLLW ft)[1]
10 to 0
0 to -10
-10 to -20
-20 to -30
Below -30
10-foot Contours[1]

0 125 250
Feet
1:3,000

Video and Tidal Current Transect Locations
Draft RI/FS Work Plan
Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING
ANCHOR QEA
FIRM: ANCHOR QEA
DRAWN BY: ckiblinger
FIGURE NO. 6-5

AQ GIS Path: Q:\Jobs\100719-01_Bremerton_MGP\Maps\2015_01_Draft_RIFSWP\ADCP and Camera Transects.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/27/2015 || User: ckiblinger || Print Date: 1/27/2015



NOTES:
1. Site-associated bathymetry from survey conducted by eTrac; provided on May 15, 2013. 0-ft contour = Mean Lower Low Water (MLLW); vicinity bathymetry from Finlayson D.P. (2005) Combined bathymetry and topography of the Puget Lowland, Washington State.
2. See Final Completion Report, Former Bremerton MGP Site, Incident Action and Time Critical Removal Action, January, 2011. Locations are approximate.
3. State Aquatic Lands - Managed by DNR
4. Anchor QEA (2013) Removal Evaluation.
5. Kitsap County (2013) Anderson Cove Beach Sediment Sampling.
6. Derived from NOAA navigational chart 18449 (US5WA14M).
7. If a paper copy is required, this figure is best printed in color.

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1. Drift cells are categorized as one of 5 types: Clockwise drift cell (right to left when looking at the shore); Counter clockwise drift cell (left to right when looking at the shore); No appreciable net shore drift (NANSD); Divergence zone; Undefined.
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3. Source: Washington Department of Ecology, Net Shore-Drift in Washington State, http://www.ecy.wa.gov/services/gis/data/oceans/driftcells.htm

Surface Sediment Grab
Far Field Surface Grab
Subsurface Core and Surface Grab
Surface Water Locations
Removal Evaluation Sample Locations[4]
Initial Study Area
Approximate Riprap Area

Surface Sediment Data Source
Anchor QEA[4]
Kitsap County[5]
Historical Structures Associated with the Gas Works
Historical Structures Not Associated with the Gas Works
Existing Buildings
Former Gas Works Location

Drift Cells*
Undefined
Divergent zone
Transport zone (left to right)
Transport zone (right to left)
No appreciable drift

2010 TCRA/IA Pipe Plug Location[2]
Cover of Existing Organoclay Mat (10-inch minus rock)[2]
Extent of Existing Organoclay Mat[2]
Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
Bathymetry/Topography Contours (MLLW ft)[1]
Site-associated Bathymetry Extent

Outfall Size (inches)
8 - 12
13 - 24
25 - 36
37 - 48

Outfall Type
Combined Storm Drain/CSO
CSO Outfall
Storm Drain

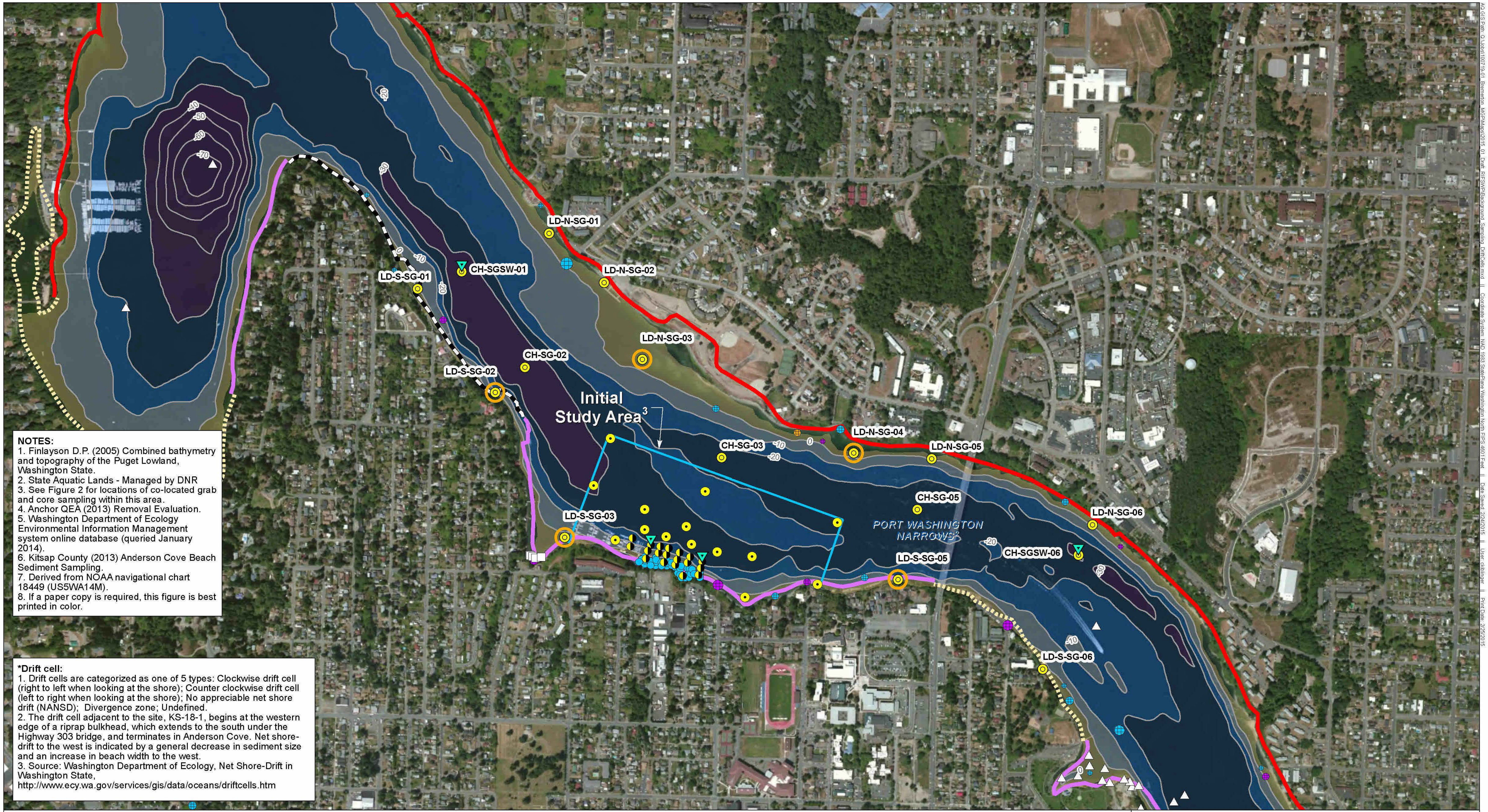
Reported Bathymetry (MLLW ft)[1]
10 to 0
0 to -10
-10 to -20
-20 to -30
Below -30
10-foot Contours[1]

0 125 250
Feet
1:3,000

Initial Study Area Sampling Locations

Draft RI/FS Work Plan
Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING
ANCHOR QEA
FIRM: ANCHOR QEA
DRAWN BY: ckiblinger
FIGURE NO. 6-6



ISA Surface Locations
Port Washington Narrows Surface Sediment Locations
Ex situ Porewater Testing
Subsurface Core and Surface Grab
Surface Water Locations
Removal Evaluation Sample Locations[4]
Initial Study Area[3]

Surface Sediment Data Source
Anchor QEA[4]
EIM[5]
Kitsap County[6]

Outfall Size (inches)
8 - 12
13 - 24
25 - 36
37 - 48
49 - 60
61 - 72
73 - 84

Outfall Type
Combined Storm Drain/CSO Outfall
CSO Outfall
Storm Drain

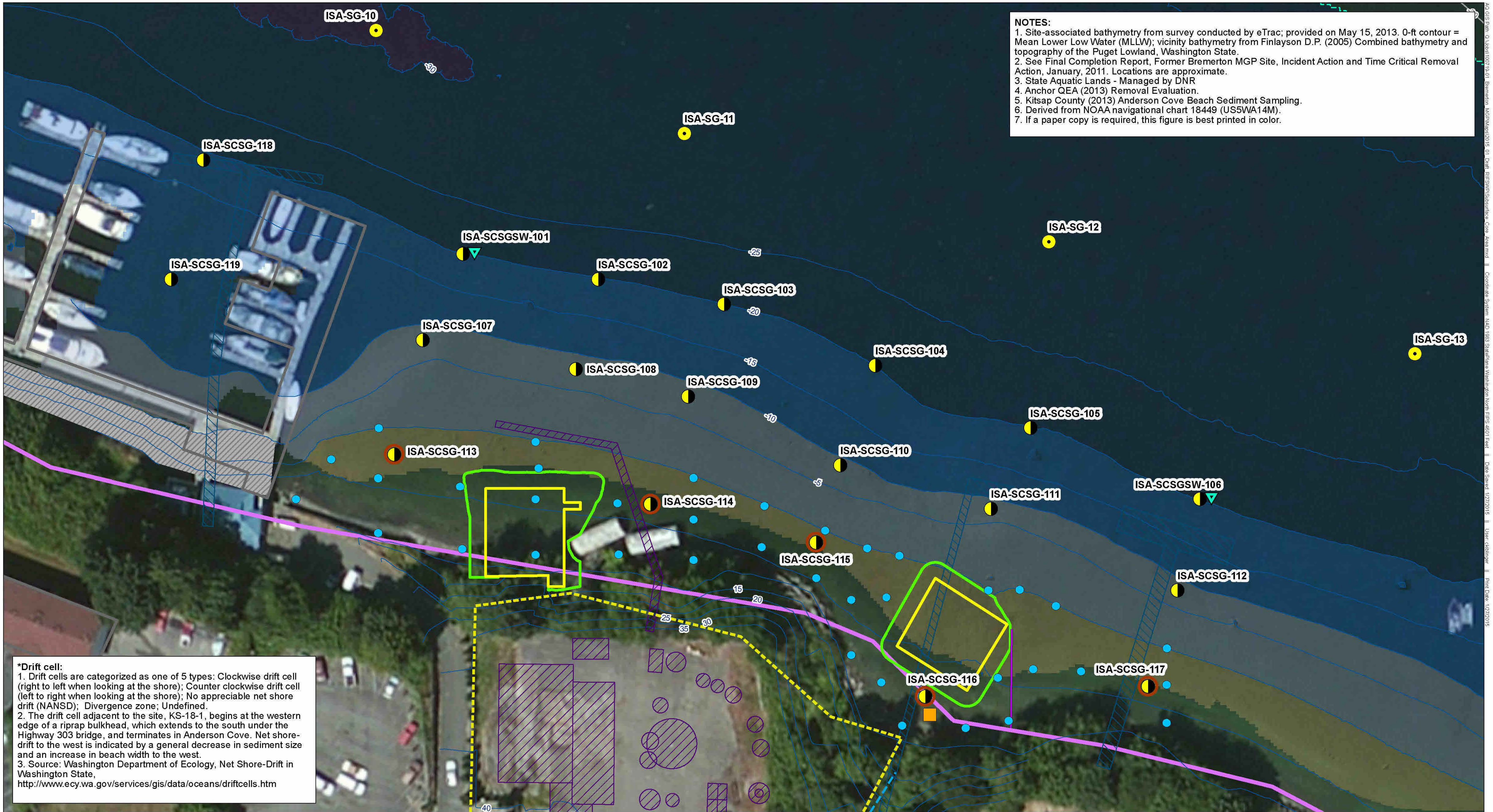
Drift Cells*
Undefined
Divergent zone
Transport zone (left to right)
Transport zone (right to left)
No appreciable drift

Reported Bathymetry (MLLW ft)[1]
10 to 0
0 to -10
-10 to -20
-20 to -30
Below -30
10-foot Contours[1]

0 400 800
Feet
1:10,000

Port Washington Narrows Sampling Locations
Draft RI/FS Work Plan
Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING
ANCHOR QEA
FIRM: ANCHOR QEA
DRAWN BY: ckiblinger
FIGURE NO. 6-7



NOTES:
1. Site-associated bathymetry from survey conducted by eTrac; provided on May 15, 2013. 0-ft contour = Mean Lower Low Water (MLLW); vicinity bathymetry from Finlayson D.P. (2005) Combined bathymetry and topography of the Puget Lowland, Washington State.
2. See Final Completion Report, Former Bremerton MGP Site, Incident Action and Time Critical Removal Action, January, 2011. Locations are approximate.
3. State Aquatic Lands - Managed by DNR
4. Anchor QEA (2013) Removal Evaluation.
5. Kitsap County (2013) Anderson Cove Beach Sediment Sampling.
6. Derived from NOAA navigational chart 18449 (US5WA14M).
7. If a paper copy is required, this figure is best printed in color.

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3. Source: Washington Department of Ecology, Net Shore-Drift in Washington State, http://www.ecy.wa.gov/services/gis/data/oceans/driftcells.htm

Surface Sediment Grab
Far Field Surface Grab
Subsurface Core and Surface Grab
Supplemental Analysis and ex situ Porewater Testing
Surface Water Locations
Removal Evaluation Sample Locations[4]
Initial Study Area

Surface Sediment Data Source
Anchor QEA[4]
Kitsap County[5]

Historical Structures Associated with the Gas Works
Historical Structures Not Associated with the Gas Works
Existing Buildings
Former Gas Works Location

2010 TCRA/IA Pipe Plug Location[2]
Cover of Existing Organoclay Mat (10-inch minus rock)[2]
Extent of Existing Organoclay Mat[2]
Assumed City of Bremerton 12-inch Storm Water Pipe Configuration
Approximate Riprap Area

Bathymetry/Topography Contours (MLLW ft)[1]
Site-associated Bathymetry Extent
10-foot Contours[1]

Drift Cells*
Transport zone (left to right)

N

0 25 50
Feet
1:700

Subsurface Core Sampling Locations

Draft RI/FS Work Plan
Bremerton Gas Works
Bremerton, Washington

Aspect CONSULTING
ANCHOR QEA

FIRM: ANCHOR QEA
DRAWN BY: ckiblinger

FIGURE NO. 6-8